THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. XII.—*On the Elastic Force of Heated Air, considered as a Motive Power;* by FREDERICK A. P. BARNARD, Professor of Chemistry and Natural History in the University of Alabama.

IN the discussions which have recently taken place with regard to the power, economy and value of hot-air engines, the attention of all who have participated in them appears to have been exclusively directed to the advantages and disadvantages presented by a particular case. The question seems not to have been contemplated in its more general aspect; or rather it seems to have been assumed that there exists no general question which the success or failure of this particular experiment will not settle. Those who are satisfied that the engines of Capt. Ericsson cannot succeed, seem ready at the same time to conclude that no engine whatever can be successful which proposes to derive its power from the same source. Experiment may prove this conclusion to be correct; but if so, it will have to be recorded as a fact in scientific history no less remarkable than true, that all those distinguished men whose labors in this branch of science have illustrated the present age, and have built up the entire theory of caloric as it is now received, have been completely in error in regard to one of their most important practical inferences, deduced from the careful study of years.

Thompson, Rankine, Joule and Regnault have all expressed the opinion that an air engine may be constructed which shall be

economically much superior to the steam engine.* One of these, Mr. Joule, has even published an outline of a plan which he would adopt in order to secure the advantages to be attained by the use of this motive power;† and he has shown, by the application of the convenient formula of Prof. Thompson, for determining what fraction of the heat expended is converted into power by thermo-dynamic engines, that an engine constructed on his plan would produce an amount of mechanical effect greater in the ratio of 6 to 5 than a condensing steam engine with fourteen atmospheres of pressure in the boiler, and in which the steam expands itself in the cylinder to the temperature of 80°. Compared with steam expanding in like manner from the pressure of five atmospheres, the economy would be nearly as 3 to 2; and taking the steam at the original pressure of two atmospheres it would be almost as 2 to 1 (1 : 1·8). But in these computations, the expansion of steam *in the cylinder* is presumed to carry the temperature down to 80°, a condition never fulfilled in practice in any steam engine. Comparing this proposed engine of Mr. Joule with a steam engine in which the expansion in the cylinder is from five atmospheres to one, as in the ordinary non-condensing engines, the result would be favorable to the air engine as $3\frac{1}{2}$ to 1. And if we compare it with a non-condensing engine at two atmospheres, we shall find that the air engine would be eight times and upward superior to the other in point of economy.

In all the discussions which the engines of Capt. Ericsson have provoked, certain propositions, which are rendered true by the peculiarities of those engines, have been tacitly assumed to be true universally; while, nevertheless, they express only the necessities of that particular case. Such are the following, viz:

1. That the available power of air engines is restricted within narrow limits by the resistance of the supply cylinders.

2. That the economy of heat in such engines is to be measured by the degree of thoroughness with which the regenerators do their work; and is therefore greatly affected by the incompleteness of the transfer of heat, both ways, between them and the air.

3. That as the first condition foregoing requires a pressure above that of the atmosphere to be carried up to the end of the stroke, there must, in the nature of things, be a great waste of heat, by the expansion of the emergent air.

* This is the important point. The air engine need not stand condemned because it will not (if it will not) drive a Collins liner. The distrust with which its prospects seem to be at present regarded, has grown mainly out of the attempt to make it accomplish labor to which it may possibly not be adapted. Air engines may always be too bulky and too ponderous to be well suited to rapid locomotion: but they may nevertheless be employed to great advantage in driving machinery or serving generally as stationary powers.

† Lond. and Ed. Phil. Mag., Jan., 1853; and Phil. Trans., 1852, Part I.

4. That a very large additional waste must occur through chimneys and flues, and by radiation from the cylinders.

5. That the leakage must be enormous, as compared with what occurs in engines driven by steam.

6. And finally, that air *cannot be heated* in such quantity, with such rapidity, and to such a degree as the exigencies of the case require.

Not one of these propositions is necessarily or universally true; and it will presently be seen that the plan of Mr. Joule is in defiance of all of them. On the other hand, it must be admitted that there are some disadvantages quite inseparable from all air engines of whatever description. It is certainly true,

1. That the mean effective pressure must, in the case of every such engine, be moderate compared with the absolute tension of the air in the cylinders.

2. That the mean effective pressure, if the engine is worked strictly with a view to economy, bears a less ratio to the absolute pressure, than it might do with less economical arrangements.

3. That a large apparatus is necessary for the development of high power, even though the power be obtained economically.

4. That the highest economy requires so large expansion of the air in the working cylinder, as to make the counteracting pressure in the supply cylinder a great inconvenience, though not an insuperable difficulty.

Professor Thompson, of Glasgow, has shown that the fractional portion of the heat which in any thermo-dynamic engine is converted into force, is represented by the range of temperature through which the elastic fluid is cooled by its expansion, divided by the maximum temperature as measured from the absolute zero (459° below the zero of Fahrenheit).* It follows that, in order to apply the force of heated air economically, there must either be large expansion in the working cylinder, or the heat remaining in the air at its discharge must be absorbed by some contrivance like Ericsson's regenerator, to be afterwards employed again. Such a contrivance, apart from its necessarily imperfect absorbing power, has the disadvantage of being confined in its usefulness within rather narrow limits. Of these limits, the upper one is the temperature required to maintain the rarefied air, at its discharge, at the pressure of the atmosphere; and the lower is the temperature produced by compression in the supply cylinders. As the pressure increases, these limits approach each other; and it is quite evident that when they meet, the regenerator becomes, not only practically but theoretically, useless.†

* As to the strict applicability of this formula to the air engine, see a note below.

† It is a curious fact that these two limits meet at precisely the pressure which (with a given supply cylinder) makes the power of the engine a maximum. For if (adopting the symbols introduced further on, and those of a former article) we

But, if we draw our supplies from the atmosphere directly, a very moderate pressure as compared with what is often employed with steam, will throw the regenerator entirely out of the question. Taking the supply cylinder at two-thirds the working cylinder, as in Ericsson's engines, supposing the external temperature to be 60°, and assuming that the tension of the air at the end of the stroke is, as economy requires, no higher than that of the atmosphere, the temperature at discharge is found by simple calculation to be 319°·5 F. Now air at 60° F. and density 1, will, on compression to density 2·692, be raised to this same temperature, and will have an elasticity of almost exactly four atmospheres. An Ericsson engine working with this pressure would derive no advantage from a regenerator. And it is furthermore evident that any approach to this limit must render the regenerator of no practical value. When, in addition to this, we take into consideration the imperfect manner in which this contrivance does its work, the degree to which its numerous meshes of wire must necessarily obstruct the passage of the air in passing into and out of the cylinder, and finally its failure to secure the advantage for which it appears to have been originally introduced, of absorbing the heat of the issuing air *above* that which is sufficient to put it in equilibrium with the surrounding atmosphere, thus making it impossible with due regard to economy, to avoid a great periodical preponderance of resistance over power, we are justified in concluding that the regenerator is by no means an important appendage of the engine, and that, very possibly, it might be advantageously dispensed with altogether.

If, however, the supplies are drawn, not from the atmosphere, but from a reservoir containing air already under a higher than atmospheric pressure; and are returned, when discharged from the cylinder, to the same reservoir, we may obtain a higher working pressure without extraordinary elevation of temperature by compression in the supply cylinder. This is the arrangement which Capt. Ericsson is understood to have adopted in his new engines. But the necessity of employing a refrigerating apparatus to keep the reservoir cool, or rather to cool down the escaping

make $\tau_{,}$ (the temperature of discharge) equal to τ' (that of compression), and observe that $\tau'=\tau''l^{\gamma-1}$, and $\tau'=\tau\left(\frac{m}{l}\right)^{\gamma-1}=\tau\left(\frac{\tau''m}{\tau l}\right)^{\frac{\gamma-1}{\gamma}}$, we shall have the equation,

$$\tau''l^{\gamma-1}=\tau\left(\frac{\tau''m}{\tau l}\right)^{\frac{\gamma-1}{\gamma}};$$

Whence $$l=\left(\frac{\tau}{\tau''}m^{\gamma-1}\right)^{\frac{1}{\gamma 2-1}}$$

which is the value of l, as shown further on, at the maximum of power. The regenerator, therefore becomes useless, when the engine is producing the greatest effect; but, by way of compensation, a materially larger proportion of the heat supplied, is converted into useful labor, than when a lower pressure is used.

air from the point at which it leaves the regenerator to its original temperature, is a great objection to such an arrangement in an engine designed for locomotion either on the water or on land.

If, on the other hand, we abandon the regenerator, we must look for our economy in enlarging the expansion in the working cylinder, and thus increasing the range of temperature through which the heated air descends in working. The disadvantage, already mentioned as accompanying this arrangement, of creating a great counteracting force, at the period at which the positive power is reduced nearly or quite to zero, must be met and disposed of by mechanical expedients. This appears to have been the view taken of the subject by Mr. Joule in the plan he has sketched of an air engine,* designed to fulfill the criterion of perfection, according to the formula (already mentioned) of Prof. Thompson. Mr. Joule's engine, like Capt. Ericsson's, employs a working and a supply cylinder, and also a receiver for the compressed air. But Mr. Joule proposes to apply the heat directly to the receiver,† and not to the cylinder; and he employs nothing equivalent to Ericsson's regenerator. The capacity of his supply cylinder is three-fourths, instead of two-thirds, that of the working cylinder. In other respects, the manner of working of the two engines is not dissimilar; but there is a great dissimilarity between them in regard to the pressure they are designed to carry, and the extent of expansion which it is proposed to give to the air.

The minimum expenditure of heat for the production of a given power in any such engine is presumed by Mr. Joule to be attained when the expansion in working brings the heated air into exact equilibrium of pressure with the atmosphere. This, it will presently appear, is not rigidly true, though nearly so. The temperature at which the air must be discharged, therefore, is according to him, definitely fixed by the dimensions of the two cylinders, when the atmospheric temperature is constant. Mr. Joule assumes the temperature of the atmosphere to be 50° F. For convenience, let us measure temperatures from the absolute zero (459° below 0° F.); then this temperature will be 509°, which we will represent by τ.

The general equation,‡

$$p' = p\left(\frac{\tau+\theta}{\tau}\right)\varrho,$$

* Lond. and Ed. Phil. Mag., Jan., 1853. In the Phil. Trans., Part I, 1852, Mr. Joule enters into some very elaborate calculations in regard to the power of air engines under various suppositions, but the plan given in the Magazine is more practical than anything contained in the previous article.

† He also proposes another and more economical mode of heating, which is noticed further on.

‡ In this equation, p is the pressure at the absolute temperature τ, and density 1; while p' is the pressure at temperature $\tau+\theta$, and density ϱ. The density at discharge (i. e. ϱ) must necessarily be to the original density in the inverse ratio of the cylinders.

making $p'=p$, and $\varrho=\frac{3}{4}$, gives $\theta=\frac{1}{3}\tau$, which is the amount of heat to be added to τ to expand the air at the constant atmospheric pressure from density 1 and temperature 509° to density $\frac{3}{4}$. The air at discharge, therefore, will be $\frac{509^\circ}{3}=169\frac{2}{3}^\circ$ above 50° F., or at $219\frac{2}{3}^\circ$ F.—equivalent to an absolute temperature of $678\frac{2}{3}^\circ$, which we will represent by τ_r.

Mr. Joule now proposes that the air shall be compressed in the supply cylinder to one-fourth its original bulk, which will make its temperature 898°·59 (=439°·59 F.); and that the air so compressed may be expanded to the relative density $\frac{3}{4}$, it must be further heated $\frac{898^\circ\cdot59}{3}=299^\circ\cdot53$, making the total maximum temperature $=1198^\circ\cdot12$ ($=739^\circ\cdot12$ F.) which we will represent by τ''. The heat of compression, 898°·59, may be put $=\tau'$.

By an application of the formula given on page 248 of the last volume of this Journal, we find the mean effective pressure of the engine working under these conditions to be 9·891 lbs. to the square inch. The absolute pressure will be, in the mean time, 105·92 lbs.

It may be objected that Mr. Joule proposes to carry his heat extravagantly high. All that can at present be said as to this point is, that the difficulty with regard to a high temperature has hitherto been to reach it. It has not yet been ascertained what degree of temperature would be seriously injurious to the materials of the machine. The great liability to loss of heat by radiation at these high temperatures, is a more serious consideration.

But Mr. Joule has undoubtedly placed his minimum temperature too low. Sixty degrees of Fahrenheit, which is the usual temperature to which scientific determinations are referred, is quite as low as we are justified in assuming the ordinary atmospheric temperature to be, in our estimates regarding a machine of this description. For though the mean temperature of the year may in northern latitudes be lower, yet as the engine is expected to work in all seasons, we ought rather to assume a temperature above the mean than below.

If we adopt 60° as the atmospheric temperature, we shall have

$$\tau'=915^\circ\cdot5\ (=456^\circ\cdot5\text{ F.})$$
$$\tau''=1220^\circ\cdot7\ (=761^\circ\cdot7\text{ F.})$$
$$\tau_r=692^\circ\ (=235^\circ\text{ F.})$$

P (mean pressure) = 9·846 lbs. to the sq. inch.
p (absolute press.) = 105·92 " " " as before.

The conditions here supposed are highly favorable to economy of heat, and do actually convert into useful labor, as will presently be shown, forty-three and a third per cent. of the caloric imparted to the air from the furnaces. They are not however alto-

gether the most favorable to the production of power, nor absolutely the best as it respects economy. Moreover they involve an absolute pressure greater than is required for the attainment of a higher mean effective pressure, and therefore a larger amount of useful labor.

By differentiating the formula already referred to, on page 248 of the last volume of this Journal,* in reference to m and l successively, we shall find that neither the ratio of capacities of the two cylinders, nor the degree of compression of the air as assumed by Mr. Joule, is that which is most favorable to power under the given working temperature.

If we make m variable, the maximum power occurs when

$$m=\frac{\tau l}{\tau''}\left(\frac{(\tau+\tau'')\gamma-\tau''l^{\gamma-1}}{(2\gamma-1)\tau}\right)^{\frac{\gamma}{\gamma-1}}.$$

For a wide range of working temperatures and for a great variety of values of l, m falls but little below unity. It seems to increase with τ'', and to diminish as l diminishes: but it is only in extreme cases that it becomes less than ·90, while it is usually above ·95, and is sometimes higher than 1·00. In the present case, with $\tau''=1220°{\cdot}7$ and $l=·25$, it is ·907, and the dependent variables will be as follows:

$\tau'=967°{\cdot}66$ $(=508°{\cdot}66$ F.)
$P=10{\cdot}447$ lbs. to the square inch.
$p=128$ " " " "

To compare the working under these conditions with the former, in point of economy, we have to observe that the expenditure of heat is directly as $m(\tau''-\tau')$, and the useful effect, directly as P. The economy will therefore be as $\frac{P}{m(\tau''-\tau')}$. The values of this expression for the two cases are as the numbers 430 and 456, nearly; or as 1 : 1·057, the condition of maximum power relatively to m, being nearly 6 per cent., the most favorable to economy.

By differentiating with respect to l, we shall find that a maximum occurs when

* This formula is repeated and reduced to a more concise form upon page 431 of the last number of the Journal. It may be rendered still more convenient for use, by substituting for the symbol k (in the last form given) its equivalent $\frac{\tau''}{\tau}$. It then becomes

$$P=\Pi a\left[\frac{m}{\gamma-1}\left(\gamma\left(\frac{\tau+\tau''}{\tau}-\left(\frac{\tau''m}{\tau l}\right)^{\frac{\gamma-1}{\gamma}}\right)-\frac{\tau''}{\tau}l^{\gamma-1}\right)-1\right]$$

in which Π is the pressure against which the engine works, a is the area of the working piston, m is the ratio of the supply cylinder to the working cylinder in cross section, l is the fractional part of the stroke before cut-off, and τ and τ'' have the values assigned them in the text.

$$l=\left(\frac{\tau m^{\gamma-1}}{\tau''}\right)^{\frac{1}{\gamma-1}}.$$

And, in the present case, τ'' being $=1220°{\cdot}7$, and $m={\cdot}75$, l will have the value ·37309 instead of ·25; and the dependent variables will be,

$\tau'=815°$ (356° F.)
P=10·823 lbs. to the square inch.
$p=70{\cdot}92$ " " " "

Comparing this arrangement with the first in regard to economy, we find it to be inferior, in the ratio of ·8264 to 1; but it has the advantage of requiring only about two-thirds as much absolute pressure in the cylinder.

Through the formulas above given, we find by a tentative process, that the absolute maximum of power under this temperature occurs, when the value of m is about 1·094, and that of l, ·4363. We have, under these conditions,

$\tau'=869°$ (410° F.)
P=12·069 lbs. to the square inch.
$p=88{\cdot}52$ " " " "

And this arrangement compares with the first, in point of economy, as ·7285 to 1. Thus the increase of power is accompanied by a more than proportional increase of expenditure, although the absolute pressure is still comparatively moderate.

The relative economy of these several arrangements, as compared with steam expanding from five or three atmospheres to one, is exhibited at one view in the following. The temperature of steam at 5 atmospheres is, according to the French academicians, 308°·8; and Prof. Thompson's formula for the per-centage of heat converted into useful labor gives,*

* The formula of Prof. Thompson is the following. Let H be the mechanical equivalent of the total amount of caloric entering any thermo-dynamic machine; let τ'' be the temperature of the elastic fluid at entering the machine, and τ_1 the same at leaving it; then $\tau''-\tau_1$ is the range of depression of temperature in working; and, putting W to represent the total useful effect, it will generally be true that

$$W=H\frac{\tau''-\tau_1}{\tau''}.$$

The formula of Prof. Thompson is applicable, however, only when the conditions conform to the definition of a *perfect* thermo-dynamic engine, as laid down by Carnot, and adopted by Thompson and Clausius:—that is to say, an engine which, by reversal, or working backward, is capable of producing the same amount of heat as is consumed in its direct action. That the air engine may fulfill this condition, the following formula must be true, viz:

$$\tau'':\tau_1::\tau':\tau, \text{ or } \frac{\tau\tau''}{\tau_1\tau'}=1.$$

The formula which, in the most general manner, expresses the amount of heat utilized, when H represents the entire amount drawn from the source, is the following:—

$$H\left[\frac{\gamma-1}{\gamma}\left(1-\frac{\tau}{\tau'}\frac{\tau''\left(\frac{\tau\tau''}{\tau_1\tau'}\right)^{\frac{1}{\gamma-1}}-\tau'}{\tau''-\tau'}\right)+\frac{1}{\gamma}\left(1-\frac{\tau_1-\tau}{\tau''-\tau'}\right)\right],$$

$$H\frac{\tau''-\tau_{,}}{\tau''}=H\frac{767{\cdot}8-671}{767{\cdot}8}={\cdot}1267\times H,$$

as the measure of the economy of working with steam under those conditions. In like manner we obtain $\cdot0861\times H$, for steam of three atmospheres. And Joule's engine gives

$$H\frac{1220{\cdot}7-915{\cdot}5}{1220{\cdot}7}={\cdot}433\times H.$$

By properly combining these numbers with the foregoing, we obtain these ratios, steam being in both cases taken as unity.

	Steam.	Joule.	Max. *m*.	Max. *l*.	Max. *m* & *l*.
5 atmospheres =	1	3·436	3·631	2 839	2 502
3 atmospheres =	1	5·031	5·321	4·153	3 665

There can therefore be no doubt of the very great economy which would attend the working of a hot-air engine, should successful ingenuity overcome the difficulties (entirely mechanical) that have hitherto, in a great measure, baffled the efforts of inventors.

I am willing to admit that the working temperature assumed by Mr. Joule is too high; or is at least higher than is to be desired: and I may add that it is higher than is necessary. But before examining what would be the effect of reducing this heat within limits to which no one could reasonably object, it may be well enough to examine one or two of the difficulties which have been mentioned earlier in this article, as having been esteemed inseparable from the use of this motive power, and insurmountable. Mr. Joule has provided against losses of heat by escape through chimneys, &c., by proposing to make the furnaces air-tight, and to pass the air through them in its way from the reservoir to the cylinder. The blast may be directed in part through the fuel; but as the entire mass of air might create unnecessarily powerful combustion if driven through the fire, the greater portion may pass over it.* It may be added that, as the difficulty hitherto has

which on supposition that the foregoing proportion holds, becomes,

$$H\left[\frac{\gamma-1}{\gamma}\left(1-\frac{\tau}{\tau'}\right)+\frac{1}{\gamma}\left(1-\frac{\tau}{\tau'}\right)\right]=H\left(\frac{\tau'-\tau}{\tau'}\right)=H\left(\frac{\tau''-\tau_{,}}{\tau''}\right),$$

which is Thompson's formula. The demonstration of this proposition is reserved for another place.

* By this arrangement the oxygen of the air is shortly converted into carbonic acid, but without change of volume, although with some small increase of specific heat. Should the plan be adopted of employing confined air previously compressed, some fresh air will require to be regularly supplied, to sustain the combustion. This may be introduced beneath the fuel, while the rest passes over it. The amount necessary may easily be computed. According to Dr. Prout, 100 cubic inches of air at the normal pressure and density weigh 31·0117 grs.; of which weight 23 per cent. is oxygen. According to Mr. Joule, one grain of coal produces by its combustion heat enough to raise the temperature of a pound of water 1°·634 F. According to Regnault, the specific heat of air at constant pressure is (taking a mean of his values) = ·23775. And, the chemical equivalents of carbon and oxygen being 6 and 8 respectively, the composition of carbonic acid, CO_2, requires that eight grains of oxygen be supplied for the perfect combustion of three grains of carbon. From these

been to heat the air with *any* power of furnace, since radiant heat produces no sensible impression on it, since there is little time for the process of convection, and since but a limited portion of it can come in contact with the surface of the heating chambers, it would be advantageous to fill the fire boxes above the fuel with meshes of wire similar to those of Ericsson's regenerators. These would arrest the radiant heat and impart it by contact to the passing air. It is Mr. Joule's plan to construct the fire boxes so that they may be shut off from communication with other parts of the engine, when they require replenishing with fuel.

The exterior of the cylinders may be protected in a good degree by non-conducting jackets not unlike those applied by Watt to the steam engine.

These arrangements not only afford a good security against waste of heat through chimneys, and by radiation, but they put the fire most completely under the command of the engineer, and they secure what has not yet been secured, the certainty that the air *will be heated* to the temperature desired.

There remains no serious objection to be considered except that which arises from the resistance of the supply cylinders. This difficulty is entirely of a mechanical nature, and it is to be surmounted by mechanical expedients. There is abundant force, but this force happens to be greatly in excess at one time, and in deficiency at another. I have already pointed out, in a former number of this Journal, in what manner the difficulty may be obviated in engines designed, like Ericsson's, to carry not more than two atmospheres of pressure. That method will answer, with a supply cylinder of three-fourths the capacity of the working cylinder, to an extent of more than four atmospheres, preserving a predominance of positive power at every point of the revolution. By attaching three piston rods to the same crank, the cylinders being placed at angles of 60° from each other, the method will answer for still higher pressures. But that other and still more

data it appears that the oxygen contained in 13 cubic feet, or one pound of air will, by the combustion of a due amount of carbon, raise the temperature of one pound of air 4152° F. A reference to the summaries presented further on in the text will show that the arrangements theoretically the most eligible, do not require a larger range of furnace heating than about 300°; while some demand no more than 200°, and while those which are likely to be most convenient in practice will make necessary only about 250°. One pound of air will therefore furnish oxygen enough to heat about fourteen pounds, or more than 180 cubic feet of air through the largest required range. It is consequently quite safe to say that one pound of fresh air introduced at each stroke would heat at least ten pounds to the necessary extent, besides heating itself and making good all waste. If three cylinders, therefore, work in connection with one crank, each cylinder capable of heating ten pounds of air of the ordinary temperature and density, they will hold under the pressure of five atmospheres, fifty pounds each, at the same temperature. If two of these cylinders be supplied from a reservoir into which air has been compressed to this degree, the third one, working against the atmosphere alone, will furnish oxygen enough to keep up the combustion. If the compression in the reservoir is less, the supply of oxygen will be proportionably in excess.

effectual methods of removing the evil may be devised by ingenious mechanics, I have no doubt. Upon this point I shall presently have something more to say.

As it is perhaps too much to expect that the air engine will ever be successfully employed to propel the largest ships, on account of its weight and bulk, it is obvious that the effective pressures which we have already seen are considerable, may be materially increased by resorting to the expedient which Capt. Ericsson is said to have adopted in his engines now in process of construction, of employing air which has been previously condensed in a suitable chamber to such a pressure as may be thought expedient. A double density only, given to such a confined mass, might furnish to the engine a mean effective pressure of more than twenty pounds; whereas not more than three or four at the outside are attainable in the engines of the "Ericsson," and only between two or three appear to have been attained.

It follows of course that engines worked on the principle of Mr. Joule's will require no such enormous cylinders as those of the experimental engines which Capt. Ericsson has abandoned; and also that they will be double acting. These modifications will effectually dispose of the trouble of leakage, which has been probably occasioned, as suggested by my brother, Maj. Barnard, in the July number of Appleton's Magazine, by the unequal expansion of the top and bottom of the working cylinders.*

I have observed that the working temperature assumed by Mr. Joule is higher than is necessary. It remains to consider what

* Still, I cannot but think that the leakage has been over-estimated, and that the lack of power which has been to such a degree imputed to this cause, has resulted from the impossibility of heating the air by the contrivances employed in the abandoned engines. The idea that "the regenerators were to be the principal source of heat" led to the adoption of furnace arrangements manifestly inadequate to the great demand upon them.

Capt. Ericsson says that he was never able to carry more than eight pounds of pressure; yet Prof. Norton and others assume a possibility of a leakage of 20 per cent. Now the capacity of Ericsson's supply cylinder is 614·2 cubic feet, and one-fifth of this amount is 122·84 cubic feet, which, on this supposition, must escape at every stroke. At 10 revolutions a minute, this would be 40·95 cu. ft. per second. Now the velocity with which air under pressure escapes into the atmosphere is represented by the expression

$$v' = v\sqrt{\frac{p'-p}{p'}}$$

in which v is the velocity with which the atmospheric air rushes into a vacuum ($= 1299$ ft. per sec.), p' is the elastic force of the confined air, and p, that of the atmosphere. Whence we obtain in the case in hand, $v' = 765.9$ ft. $= 9191$ inches. And 40·95 cu. ft. contain 70761 cubic inches, which would require an aperture equal to $\frac{70761}{9191} = 7.7$ sq. inches to admit of their escape in one second. Such a leakage as this is incredible. Maj. Barnard (Appleton's Mag. July, 1853,) reduces the supposed leakage to $\frac{1}{18}$, which is still 11·373 cu. in. per sec.—equal to the escape from a free aperture of 2·139 sq. inches. It appears to me that even this estimate is largely excessive. The "hole half an inch in diameter" which Capt. Ericsson permitted to remain open in the reservoir of one of his engines, was a trifle to this.

would be the effect upon the available power, of considerably reducing this. Still retaining the relative dimensions of the cylinders proposed by him, I will first assume a compression in the supply cylinder to one-third the original bulk. This will give an absolute temperature of 813°·8, (= 354°·8 F.) which will be required to be further raised to 1085.07 (= 626°07 F.). That this temperature is admissible if it can be reached, I have no doubt. By this arrangement we shall obtain a mean available pressure of 7·33 lbs. to the sq. inch, under an absolute pressure of 70·56 lbs., and with an economical superiority to the non-condensing steam engine of five atmospheres, of nearly three to one.

But in order to show that the economical advantages belonging to this method of employing air are to a great extent attainable under much lower temperatures, I will suppose that Mr. Joule's principle is applied to an engine working under the temperature upon which all my former computations were founded, viz., 450° above the temperature of melting ice, or 482° F. We find that, under this temperatue, when $r_{,}$ is made equal to r', the mean pressure becomes 4·61 lbs., and the absolute pressure 43·22 lbs. to the sq. inch, while the economy, compared with steam, as above, is more than two to one.

In the following summary statements, are exhibited at one view all the particulars relating to the several cases under each of the three temperatures which have been considered. In these tables θ stands for the temperature, Fahrenheit, produced by compression; i. e., $\theta = r'-459°$; R stands for the ratio of economy as compared with steam expanding from five atmospheres to one; and R′ represents a similar ratio, steam of three atmospheres expanding to one being taken as unity.*

$$r'' = 1220°7 = 761°7 \text{ F.}$$

	m	l	P	p	θ	R	R′
Joule,	·750	·250	9·85	105·92	456°·5	3·436	5·031
Max. m,	·907	·250	10·45	128·00	508°·7	3·631	5·321
Max. l,	·750	·373	10·82	70·92	356° 0	2 839	4·153
Abs. max,	1·094	·436	12·07	88·52	410°·0	2·502	3·665

* In order that a comparison may be made with Capt. Ericsson's abandoned engines, in which he proposed to carry a pressure of 12 pounds (above the atmosphere) in his reservoir, while l was made $= \frac{5}{4}$, we observe, first, that these conditions require a working temperature of 592° F, which is nearly equal to the medium temperature proposed above. We shall have then for Ericsson's arrangement,

$$r'' = 1051° = 592° \text{ F.}$$

m	l	P	p	θ	R	R′
·667	·750	4·35	27	156°·6	1·195	1·750

These values of R and R′ suppose no regenerator to be used. The regenerators, if perfect in their action, would make R = 3·153, R′ = 4·167. Allowing that they fail to the extent of 30°, as stated by Capt. Ericsson, the values would be R = 2·668, R′ = 3·907.

$t'' = 1085°{\cdot}07 = 626°{\cdot}07$ F.

	m	l	P	p	θ	R	R′
Joule,	·750	·333	7·33	70·56	354°·8	2·877	4·212
Max. m,	·917	·333	7·87	86·26	403 ·7	3·087	4·530
Max. l,	·750	·420	7·63	55.98	301 ·8	2·507	3·670
Abs. max,	1·021	·478	8·76	67·00	342 ·6	2·412	3·539

$t'' = 941 = 482°$ F.

Joule,	·750	·472	4·61	43·22	246°·7	2·086	3·054
Max. m,	·928	·472	5·14	53·49	291 ·9	2·325	3·404
Max. l,	·750	·488	4·65	42·00	241 ·0	2·054	3·007
Abs. max,	·960	·538	5·16	48·55	271 ·5	2·034	2·977

It appears from these summaries, that the arrangement most favorable to economy is that in which, the cut-off remaining where Mr. Joule's principle would fix it for the given supply cylinder, this same supply cylinder is enlarged to the dimensions which give the maximum of power for that cut-off. It also appears that the conditions which furnish the *absolute* maximum of power for the *temperature*, are the least economical of those which the table embraces.

Two double action cylinders fixed at right angles to each other, with their piston rods attached to the same crank, will, with the arrangements proposed in my September article, preserve a preponderance of positive power throughout the stroke, whichever of the above proportions are adopted under the temperature of 482° F.

For the higher temperatures, three cylinders, or four, would be necessary; unless some new mechanical expedient should be resorted to, to reduce the resistance at the end of the stroke. Such an expedient it was a part of the design of the present article to propose—not as the best possible, for it has not been a subject of much study—but merely for the sake of illustrating the practicability of overcoming what has been regarded as a formidable difficulty in the way of the success of the air engine. It would extend this article, however, beyond reasonable limits, to attempt a particular description of the contrivance here. It may be sufficient to say that it is a contrivance for causing the piston at the period of maximum power to encounter and overcome the maximum resistance:—that is to say, to throw the burthen of driving into the reservoir a charge of air fully condensed by a previous stroke, upon the first third of each stroke, (or first fourth, if Mr. Joule's proposed temperature be adopted,) and to leave to the last two-thirds, only the labor of bringing a new charge to the required density.* By this means, the great resistance which,

*It is obvious that this might be effected, by so adjusting the cranks that the driving piston may begin its stroke just as the air in the supply-cylinder reaches the maximum of condensation. It is desirable, however, to avoid the severe strain upon the shaft which this plan would occasion: and hence the method hinted at in the text is made to rest upon a different principle.

under the ordinary arrangements, extends over all that period when the driving power is approaching zero, is easily disposed of, and the remaining resistance only becomes serious when the companion piston possesses a powerful mechanical advantage over it. The mechanism which I would propose is simple and liable to no objection at present discoverable; yet I have no doubt that other contrivances might be devised to accomplish the same end as well or better. I shall consider, therefore, the resistance of the supply cylinder as no longer entitled to very grave consideration; and, if it were, a heavy fly wheel would be a sufficient regulator for stationary engines of moderate power. For as the engine may be *started* with a cut-off which produces *no* counter resistance, there can be no difficulty in putting the regulator in motion.

It is sufficiently obvious that, for all the ordinary purposes to which stationary engines are applied—that is, for all purposes in which immense power within limited bulk is not an indispensable condition—the air-engine may take the place of steam with an economical advantage of at least two, and probably three, to one. It remains only to examine what dimensions would be necessary to create a power equal to that employed to propel the great ocean steamers.

There can be no doubt that the effectual modes of heating which may be made to supersede the very imperfect arrangements of the "Ericsson," will render possible a material increase in the velocity of the piston. That at least twelve revolutions may be obtained with an eight foot stroke is a moderate estimate. Under the lowest of the foregoing assumed working temperatures, (482° F.) a mean pressure of more than five pounds is obtained; but we will assume one lower than the lowest, that is, $4\frac{1}{2}$ lbs. per sq. inch. Now one double-action six foot cylinder with a stroke of eight feet, twelve revolutions, and a mean pressure of four and a half pounds, will give an aggregate horse power of $106\frac{1}{4}$. Let the air be drawn from a chamber in which it has been previously compressed to the density of four times that of the atmosphere, and the power will be 425. Two such cylinders will give 850 aggregate horse power. A third one working in connection with them against the pressure of the atmosphere alone, in order to feed the fires with oxygen, will raise the total to 956 horse power.* These three may more than answer to a single marine engine; and a second similar set will give an entire aggregate of 1912 horse power. The whole six, with their accompanying supply cylinders would not exceed in weight, if they would equal, the four large pairs of cylinders on the "Ericsson."

* If the air he heated without coming into actual contact with the fuel, the three cylinders may all be supplied from the reservoir, and by making them only five feet each in diameter they will give an aggregate horse power of 855. This doubled will furnish more than the average power of the large ocean steamers.

If however, we adopt the higher temperature of 626° F. to which there is as yet no well established objection, we may obtain an equal power with much smaller cylinders. The tables show that it is practicable to obtain nearly 9 pounds of available mean pressure under this temperature, when working only against the atmosphere; and this moreover with an economy which, though not absolutely the highest, is considerably higher than any that is attainable under a lower temperature, and nearly two and a half times superior to that of steam of five atmospheres. Now if we compress air into the air chamber to the extent of five atmospheres, and work two cylinders of each set against this pressure, while the third works against the atmosphere alone, we shall require no larger diameter than 45 inches for each of our cylinders to enable us to obtain 1750 horse power, which is equal to that of a first class steamer. If then we increase the diameter to 48 inches, we shall have more than 2000 aggregate horse power, which enables us to allow nearly a sixth part for friction and other drawbacks.* The weight of the cylinders themselves will no longer be an objection. That of the air-chamber, heaters and refrigerators may be a more serious matter; how far it will be so will soon be settled by the experiments of Capt. Ericsson. It may be remarked, however, that the apparatus must be a heavy one, indeed, which will materially outweigh the boilers of the ocean steamers.†

In making these estimates of power, I have not overlooked the manner in which the velocity of the piston is controlled by the increased or diminished resistance, as pointed out by Maj. Barnard in Appleton's Magazine for October. It will be found, upon the principles of estimate adopted by him, that too low rather than too high a velocity of piston is here assumed. I admit the conclusiveness of all that Maj. Barnard has said in regard to the insufficiency of the original Ericsson engines to perform the task

* If again all these cylinders work against the reservoir, 38 inches will be as large a diameter as is necessary, and 40 inches will afford nearly 200 horse power surplus.

† All the estimates of power made in this paper have been founded on suppositions of pressure to which no serious objection can be taken. But as the power is always directly as the pressure in the air chamber, there is plainly no limit to its increase except the strength of materials. The question of bulk or compactness is also dependent upon the same considerations. With a pressure of 20 atmospheres in the air chamber, a single twenty-inch cylinder (the other suppositions remaining as in the text) would give 300 horse power; and a forty-inch, 1200. Two thirty-six inch cylinders would give 1950 horse power; *more* than enough to drive the largest ocean-liner, after making every deduction for waste and unproductive expenditure of power. Two six-foot cylinders would furnish equal power with but five atmospheres of pressure in the air-chamber. But the cylinders themselves would have to endure a pressure of more than twenty atmospheres. These are the dimensions adopted by Capt. Ericsson for his working cylinders in his new engines; but as the supply-cylinders are less than our supposition, and the compression which the air undergoes in them also less, (as it must be so long as it is proposed to make the regenerators of any use,) the power which these engines will develope must be correspondingly inferior. They are considered and compared with the abandoned engines, in a note published in the last number of this Journal.

imposed upon them. The thoroughness with which he has examined that part of the subject leaves nothing further to be said. But nothing which he or any one else has asserted or proved in regard to those engines in any manner invalidates the truth of the following conclusions, viz :

1. That the elastic force of heated air is a force available for all the purposes for which stationary powers are required.

2. That it is an eminently economical source of power ; being in this respect superior to steam, as usually employed, in the ratio of two or three to one.

3. That while it appears to be at present more doubtful to what extent it is applicable, if at all, to the purposes of ocean navigation, its value in that respect remains yet to be experimentally settled.

University of Alabama, Nov. 2, 1853.

ART. XIII.—*Researches on Globuliferous Rocks ;* by M. DELESSE, Ingenieur des Mines, Professeur Honoraire de Geologie à la Faculté de Besançon.

[THIS important paper by M. Delesse, is published in the Transactions of the Geological Society of France, and is one among the many contributions of its author to our knowledge of the structure of rocks and their minerals.* We give our readers an abstract of it, presenting the prominent facts and the author's conclusions. The article is illustrated by several elegant plates, only a few figures from which we have copied.—EDS.]

Under the name of GLOBULIFEROUS ROCKS, those rocks are designated which contain certain minerals disseminated through

* The following are the titles of some of the papers of M. Delesse on these subjects.

1. Note sur le Chrysotil des Vosges.—Ann. de la Soc. d'Emulation des Vosges, vi, 2nd Cahier, 1847.

2. Recherches sur les Verres provenant de la Fusion des Roches.—Bull. de la Soc. Geol. de France, [2], iv, 1380, 1847.

3. Notice Sur les Caractères de l'Arkose dans les Vosges.—Bib. Univ. de Geneve, March, 1848.

4. Procédé Mécanique pour déterminer la Composition Chemique des Roches.—Bib. Univ. de Geneve, July, 1848.

5. Observations sur la presence d'eau de Combinaison dans les Roches Feldspathiques.—Bull. de la Soc. Geol. de France, [2], vi, 393, 1849.

6. Sur le pouvoir Magnetique des Roches.—Ann. de Ch. et de Phys., 1849, xxv, 194, and Annales des Mines, [4], xiv, 81, 429, and xv ; xvi, 323, 1849.

7. Recherches sur le Porphyre Quartzifère.—Bull. de la Soc. Geol. de Fr. [2], vi, 629, 1849.

8. Sur le Porphyre Amygdaloide d'Oberstein.—Ann. des mines, [4], xvi, 511, 1849.

9. Recherches sur l'Euphotide.—Bull. Soc. Geol. de France, [2], vi, 547, 1849.

10. Sur la Constitution Minéralogique et Chemique des Roches des Vosges: Pegmatite avec tourmalines de St. Etienne.—Ann. des Mines, [4], xvi, 1849.

11. Sur la Constitution Minéralogique et Chemique de la Syenite du ballon d'Alsace, Mem. de la Soc. d'Emulation du Doubs. 1847.

12. Sur la Protogine des Alps.—Bull. de la Soc. Geol. de France, [2], vi, 230, 1849.

13. Serpentine des Vosges, Ann. des Mines, [4], xviii, 309, 1850.

them more or less thickly in globules.* These globules are generally feldspathic, and this memoir has especial reference to those of this kind, occurring in rocks that are rich in silica.

Granites are sometimes globuliferous, as those of Rappawiki, in Finland, which contain globules consisting of orthoclase, surrounded by oligoclase. But these researches relate particularly to porphyritic or compact rocks, especially eurite, pyromeride, trachyte, retinite, perlite, obsidian, and a large variety of porphyries. The pyromerides of Corsica and the Vosges, the porphyries of Esterel, of the country of Bade and Thuringia, the trachytes of Iceland, the retinites of Saxony, and the perlites and obsidians of Hungary, are taken as types of this structure.

The globules vary much in color, being either black, violet, green, brown, yellowish, reddish, gray or white; usually differing a little from the color of the paste. They are commonly harder than feldspar, when undecomposed, owing probably to the excess of silica; but in perlites they are less hard than feldspar, perhaps because the mineral is in a semi-vitreous state, and also, it may be, because opal penetrates them, as stated by Hausmann and Fuchs. The specific gravity is low, viz. 2·3–2·6; 2·3–2·4, in perlite. This is far less than for quartz, which has G. = 2·65. Before the blowpipe, they fuse less easily than feldspars, owing to the excess of silica and small proportion of alkalies.

Composition:—

	Si	Al	Fe	Mn	Ca	Mg	Na	K	ign.	
1. Fr. Pyromeride, Wisenheim,	88·09	6·03	0·58	—	0·28	1·65	2·53		0·84	=100, *Delesse.*
2. Fr. Perlite, Hlinick, Hung.,	79·12	12·00	2·45	—	—	1·10	3·58		1·76	=100·01, *Ficinus.*
3. Fr. Trachyte, Bhula,	74·38	13·78	1·94	1·19	0·85	0·58	3·57	2·63	2·08	=101·00, *Forchh.*
4. Fr. Retinite, Saxony,	73·00	14·50	1·00	0·10	1·00	—	1·75		8·50	=99·85, *Klaproth.*
5. Fr. Perlite, Saxony.	68·53	11·00	4·00	2·30	8·33	1·30	3·40		0·30	=99·16, *Erdmann.*

The large excess of silica is the remarkable characteristic, and as a general rule in the pyromeride, the composition of the globules is the inverse of that of the enveloping rock.

Structure.—The globules have generally a well defined structure. In most of the pyromerides of Corsica and the Vosges,

14. Recherches sur l'Association des Mineraux dans les Roches qui ont un pouvoir magnétique élevé.—Bull. de la Soc. Geol. de France, [2] vii, 108, 1850.

15. Sur la Variolite de la Durance.—Ann. des Mines, [4], xvii, 116, 1850.

16. Recherches sur le Porphyre Rouge Antique et sur la Syénite Rose d'Egypte. Bull. Soc. Geol. de France, [2], vii, 484, 524, 1850.

17. Sur le Porphyre de Lessines et de Quenast (Belgique).—Bull. Soc Geol. de France, [2], vii, 310, 1850.

18. Sur la Constitution Minéralogique du Diorite, Kersantites.—Ann. des Mines, [4], xix, 149, 1851.

19. Sur la Constitution Minéralogique de la Calcaire Saccharoide du Gneiss. —Ann. des Mines, xx, 141. (1851.)

* This subject has already received some attention—see especially, von Buch, *Recueil de planches de Petrifications remarquables*, fol.; R. C. von Leonhard, *Charakteristik der Felsarten*, p. 52; Al. Brongniart, *Essai sur les Orbicules siliceux*, Ann. Sci. Nat. [1], xxiii, 166; Naumann, *Lehrbuch der Geognosie;* Roth, *Die Kugelform im Mineralreiche und deren einfluss auf die Absonderungestalten der Gesteine.*

and in the porphyries of l'Esterel and Oppenau, the silicious and feldspathic parts differ in color: and the distinctions of the two are often brought out in decomposition, the silicious part resisting change, while the feldspar is kaolinised. Acids (especially hydrofluoric) develop the structure in a short time.

The globules may be either solid throughout, or they may contain interior cavities: the former I call *normal* globules: the latter *abnormal*.

Globules of both kinds are usually spherical or spheroidal, and have either a *radiated*, *concentric*, or *irregular*, structure; these three kinds of structure may occur in the same globule. They detatch themselves readily from the enclosing rock, and present usually an even surface. They undergo alteration less rapidly than the enclosing rock. These globules sometimes contain crystals of quartz or feldspar, which obviously do not concur to the formation of the globules, and which, therefore, are *independent crystals*.

The excess of silica in the feldspathic paste, is considered an excess of a solvent, as is admitted by M. Delafosse, for different silicates.

Normal globules may either contain quartz or be free from it.

Normal globules without quartz.—When globules of this kind have a crystalline structure, there are usually distinct cleavages. They are frequently observed in quartziferous, porphyrites, or eurites. Figure 1 represents one of these globules

1. 2. 3.

from the Eurite of Etival (Vosges), a rock consisting of orthoclase, a triclinic feldspar, a little quartz and mica; the globule approaches in form a crystal of orthoclase, and is cleavable and transparent, and it is surrounded by a thin milky or reddish compact zone of a feldspar which is probably triclinic. In certain micaceous eurites of the Vosges (Minettes), the globules are spherical and consist of feldspathic lamellæ, probably of orthoclase, irregularly aggregated, along with some mica, and they have a reddish exterior like the above. When the structure is radiated, there is but a single system of rays, diverging from the centre; the radiation is often very rude. At Oppenau, the feldspar forms but a small part of the globule, it being surrounded by chalcedony. Yet it is evident that the globule has resulted from the tendency of the feldspar to crystallize and to bring under the same influence, the silica.

The globules in obsidian are usually more or less radiated, and sometimes have an exterior coat or layer. They resemble much those found in the crucibles of a glass furnace when slowly cooled. Perlites and retinites, even when apparently compact, consist wholly of globules which may be distinguished when carefully examined; and the structure is very irregularly and sparingly concentric, with some cross fractures (fig. 3).

Normal globules with quartz.—Globules without quartz pass insensible into those with quartz. The latter appear to differ only in that the quartz has been imprisoned within, in consequence of the solidification of a crystalline crust. The structure is either radiated or concentric, and both kinds may occur together. The rays consist of feldspar needles or conoids separated by quartz; and both at the circumference and centre there are often zones of feldspar alternating with quartz.

The structure of the globules of the pyromeride of Corsica is shown in the following magnified view.

4.

There are irregular exterior zones of feldspar of different shades, *u;* needles or conoids of feldspar converging from the zones towards the centre, and others diverging from the centre outward, the two sets much interlaced; the forms and structure of these conoids are very irregular, and sometimes they become isolated globules. Quartz penetrates the whole, and is also to a considerable extent free and glassy (*b*), filling the spaces or forming zones. Sometimes the quartz is much more abundant at the centre than at the circumference. The quartz is beautifully brought out by means of hydrofluoric acid; but it should be observed that hyaline quartz is much less readily attacked than chalcedony or opaque quartz.

Abnormal globules.—These globules contain cavities, which may be regular or confused, filled or unfilled; and they have been produced either by *contraction* or *expansion*. Globules with cavities formed by contraction are common in the trachyte and other rocks of Iceland. One of these enlarged is shown in fig. 5. The cavities are of irregular form and surface. Sometimes they have been filled with quartz, and occasionally with oxyd of manganese, spathic iron, zeolites, barytes, calcite, etc. At Llanberis in Wales, the globules are sometimes a decimeter in diameter, and the cavities contain quartz crystals, and outside of the quartz a layer of ripidolite. Others in retinite contain one or more layers of chalcedony with sometimes an exterior zone of opal and an interior of quartz crystals, or a kind of jasper in layers or bands.

5.

In other globules the cavities are numerous and confused; and often they have been filled with quartz, which may be quite distinct from the feldspar or shade into it. In Corsica, the cavities sometimes contain specular iron with or without quartz; it is implanted in the quartz when this mineral is present.

The *independent* crystals of globules, occurring in the feldspathic paste constituting them, may be either quartz, orthoclase, a triclinic feldspar, hornblende, mica, specular iron, pyrites; and occasionally also, these form independent globules. In such globules the radiated structure is generally quite confused. Veins or seams of quartz also at times intersect the globules.

The most invariable characteristic of the rocks containing globules, is their holding an excess of silica; and in a given rock they are especially developed where the silica is most prevalent. By this presence of silica, connected in some cases with the penetration of the rock by veins of quartz, the occurrence or the formation of the globules has been determined. Moreover, all the globuliferous rocks are feldspathic; and the feldspar, which

would ordinarily have appeared as crystals, has taken the form of globules. The excess of silica has acted as an impurity in the mass, hindering the formation of regular crystals and leading to radiated and globular concretions. It may have acted also by causing too rapid a solidification for perfect crystallizations of the feldspar. Besides, there was a kind of repulsion between the feldspar and the excessively silicious paste, which was superior to the molecular crystallogenic forces tending to form crystals of the feldspar, and which by acting upon all sides of the agglomerations, reduced them to spheroidal globules.

In the globules of normal form in the pyromeride of Corsica, —which are characterised by exterior feldspathic layers, the outer very quartzose, the inner less so, and a semi-radiated structure within—it appears that the exterior was first consolidated, since these layers are not only very impure, but also support the convergent needles or conoids of feldspar within; the divergent needles from the centre fill up the spaces between the convergent ones, and arise from a solidification nearly cotemporaneous, beginning at the centre, where there is often a zoned feldspathic paste, as a nucleus, which is very siliceous. The solidification of the feldspar appears to have a repelling action on the silica, driving it either to the circumference or the centre. Thus, cooling from the circumference, and cooling from the centre, may occur together, or the former may alone characterize a globule, where its structure is made up of convergent needles alone. When consisting only of divergent needles, or when throughout zoned, it is considered probable that the solidification took place simultaneously throughout. The silica fills all the interstices between the feldspar needles and zones; it was solidified after the feldspar as in granite. The needles or conoids usually contain a quartz nucleus, so that they are analogous in structure to a globule; the solidification beginning at the surface, the excess of silica was driven to the interior of the conoid.

The abnormal globules, which owe the presence of cavities to *contraction*, cannot have derived these cavities from contraction after reaching the solid state. The cavities are too large to be thus accounted for by a cause which will explain only the occurrence of fissures. But in the liquid or pasty state, the circumstances are different, especially as a *process of desiccation* may have been in progress. Rocks of aqueous origin often contain concretions of concentric structure, which contain large cavities that have resulted from a desiccation of the nodule after the exterior was solidified. They may be argillaceous, silicious, calcareous, etc. Among the *argillaceous* are the *septaria* of the London clay; of the *silicious*, there are the brown zoned quartz of Egypt, which contain quartz crystals within, and also the concretions common in different deposits, especially the chalk, as the *klappersteine* or Achilleum resonans of the chalk of the Isle of Moen.

The *calcareous* include pisolites, the priapolites of Castres, the *kupstein* of the Loess, etc. There are also the *ferruginous*, consisting of argillaceous carbonate of iron, the Etites; also the *cupriferous*, such as the balls of carbonate of copper of Chessy.

The cavities of these concretions have been formed by contraction while the mass within was in a pasty state. Such cavities after they have been once formed are often filled by infiltrated material, as carbonate of lime, barytes, spathic iron, etc.

In igneous rocks, this process of contraction by desiccation may often be distinguished. In amygdaloids the cavities of the nodules of chalcedony containing crystallized quartz within, are often angular, as if formed by this means. In the Vicentine, the nodules contain angular cavities like those of the abnormal globules above described. Consequently water has performed a part in the formation of amygdaloidal nodules as well as in the formation of rocks of igneous origin. The silica of chalcedonic nodules was originally, as has been suggested, in a gelatinous state; and when owing to the dense condition of it, there was no contraction, the chalcedony entirely filled the cavity, either as a compact or a zoned mass.

But when the silica solution was very fluid, the chalcedony was left in the bottom of the cavity, as occurs at the Giant's Causeway, where the amygdala partly fill the cavities and have a nearly plane upper surface. Generally the solution was less liquid, though still as Breithaupt has observed, sufficiently so to undergo contraction on drying and afford the cavities within that are now filled with quartz crystals and other minerals. The regular form of the cavity may be owing to the compactness of the enclosing rock, allowing only of very slow drying. The zones in the chalcedony or quartz are a result of the process, showing perhaps intermissions in its progress, or in the molecular attractions in the material present affording the coloring of the layers.

In some cases the abnormal globules have probably been formed through *contraction by fusion*. It is important to observe that the *independent* crystals present in these globules, show no trace of the contraction which has been experienced by the abnormal globules; although often thin or delicate, they have not been in any way distorted, or broken. These facts authorize the conclusion that the crystals are subsequent in origin to the formation of the cavities. Hence the cavities must have been formed during the state of partial fusion, before the crystallization of these minerals took place.

From the characters of the cavities and their surfaces, it is inferred that they have probably resulted from the volatilization of water while the globules were still in a liquid state. It might be objected to this view that normal and abnormal globules often occur together. Still the presence of water is altogether proba-

ble, and we cannot conceive of any other volatile ingredient being concerned. It is hence altogether probable that these abnormal globules at first contained silica in the state of a hydrosilicate, or a jelly rich in silica; the water was at first retained by the pressure or the heat causing the spheroidal state; and afterwards it gradually escaped, and thus occasioned the contraction and the formation of the cavities.

In abnormal globules having cavities formed *by expansion*, these cavities have beyond doubt been produced by a disengagement of volatile substances, which has taken place while the rocks were still fluid. When the volatile substances were simply gaseous, they formed no deposit in the cellules; but when they carried along other substances, cooling would lead to a crystallization of different minerals on the walls of the cellules. These minerals are those composing the rocks, especially feldspar, quartz and mica: and in fact it has been found at Sangerhausen that feldspar may be deposited by sublimation in furnaces.*

In some cases, there has been an expansion by gaseous substances, producing an enveloping cellule, and afterwards a contraction forming a feldspathic globule at the centre of the cavity. In other cases, the expansion has taken place within the globule while the paste was still soft, producing a multitude of small cellules. These cellules have been afterwards filled by chalcedony.

Filling of the cavities.—The filling of the cavities has taken place either by secretion, infiltration or by both combined. In the filling of septaria, there may be a secretion of carbonate of lime or iron along the walls of the fissures, and also an infiltration filling up the rest of the cavities, the two processes producing deposits of different kinds or colors. In the filling of a mineral vein also, both processes have often operated, *secretion* introducing a part of the minerals, and *infiltration* another portion.

The infiltration of the silica into cavities, may have been either slow or rapid; the slow producing crystals, the more rapid forming chalcedony. Both processes, secretion and infiltration, may at different times have acted. Agates of the melaphyres have resulted from the penetration of the cavities with gelatinous silica, which is easily dissolved in hot water, when this water is under pressure and is charged with carbonic acid.

The same causes account for the threads or veins of quartz which intersect the globules.

The feldspar of the globules may be either orthoclase or a triclinic feldspar. The *abnormal* globules rather than the *normal*, are developed in globuliferous rocks, which are rich in soda. When orthoclase and a soda feldspar occur together, the latter is in

* Scacchi has recognized in a recent paper, (Rendiconto della R. Acad., Napoli, 1852,) that mica, quartz, garnet, hornblende, pyroxene, sodalite, nepheline and other silicates may form by sublimation.

the smaller crystals; and this inferior tendency to crystallization thus indicated, may be the reason for the formation in such rocks of *abnormal* globules which are less crystalline than normal globules.

In conclusion it may be observed that the theory here proposed is universal in its application to all globules or concretions, both those of sedimentary and igneous rocks.

One deduction of interest deserves to be noted. It is that as the vapor of water and volatile substances have acted an important part in the formation of globules, the theories for explaining the origin of granite and feldspathic rocks, ought necessarily to include this agency; for it follows that the feldspars, including orthoclase, may be formed even in the presence of water.

ART. XIV.—*Examination of some Deep Soundings from the Atlantic Ocean;* by Prof. J. W. BAILEY, West Point, N. Y.

IN an account of a microscopical examination of soundings made by the U. S. Coast Survey near the Atlantic coast of the United States* I made known that the soundings along the coast, from the depth of 51 fathoms S. E. of Montauk Point, to 90 fathoms S. E. of Cape Henlopen were chiefly made up of vast amounts of Foraminiferous shells, rivalling in abundance the deposits of analogous fossil species which I had proved to compose immense beds under the city of Charleston, S. C.

The facts were also mentioned that none of the species found in the soundings belong to the littoral genera of the group *Agathistegues* of D'Orbigny (*Plicatilia*, Ehr.) and that they also differed from those found in the tertiary deposits of Maryland and Virginia. These facts were confirmed and extended by the observations of F. de Pourtales in his Report to Prof. A. D. Bache, on the distribution of Foraminiferæ on the coast of New Jersey as shown by the off-shore soundings of the U. S. Coast Survey.†

In this paper Mr. Pourtales states that "the greatest depth from which specimens had been examined is two hundred and sixty-seven fathoms, and there the Globigerina are still living in immense numbers." He adds that the region of Globigerina extends to a depth not known.

I am indebted to that zealous cultivator of science, Lt. Maury of the National Observatory, for an opportunity to examine the deep sea soundings made by means of Brookes's lead on board the U. S. Dolphin by Lt. Berryman. These soundings proved to be of great interest and furnished results which have an important bearing upon Geology and Physical Geography.

* See Smithsonian Contributions to Knowledge, vol. ii, Art. 3.

† See Proceedings of American Association for the Advancement of Science, 1850, p. 84.

The soundings examined were as follows:

1080	fathoms,	Latitude	42°	04′	North,	Longitude	29°	00′	West,	July 25, 1853.
1360	"	"	44°	41′	"	"	24°	35′	"	" 18, "
1580	"	"	49°	56′	30″	"	13°	13′	45″ "	Aug. 22, "
1800	"	"	47°	38′	"	"	09°	08′	"	No date.
2000	"	"	54°	17′	"	"	22°	33′	"	" "

As these soundings are believed to be the deepest ever submitted to microscopic examination, and were obtained at localities far remote from those previously noticed, they were studied very carefully, and the following are the facts ascertained:

1. None of these soundings contain a particle of gravel, sand, or other recognizable unorganized mineral matter.

2. They all agree in being almost entirely made up of the calcareous shells of minute, or microscopic Foraminiferæ (*Polythalamia*, Ehr.), among which the species of *Globigerina* greatly predominate in all the specimens, while *Orbulina universa*, D'Orb., is in immense numbers in some of the soundings, and particularly abundant in that from 1800 fathoms.

3. They all contain a few species of non-parasitic or pelagic Diatoms, among which *Coscinodiscus lineatus*, *C. excentricus*, and *C. radiatus* of Ehrenberg, are much the most abundant.

4. They all contain a few siliceous skeletons of Polycistineæ, among which are several species of *Haliomma*, *Lithocampe*, &c.

5. They all contain spicules of sponges, and a few specimens of *Dictyocha fibula*, Ehr.

6. The above mentioned organic bodies constitute almost the entire mass of the soundings, being mingled only with a fine calcareous mud derived from the disintegration of the shells.

7. These soundings contain no species of Foraminifera belonging to the group of *Agathistegues* (*Plicatilia*, Ehr.), a group which appears to be confined to shallow waters, and which in the fossil state first appears in the tertiary, where it abounds.

8. These soundings agree with the deep soundings off the coast of the United States, in the presence and predominance of species of the genus *Globigerina*, and in the presence of the cosmopolite species *Orbulina universa*, D'Orb., but they contain no traces of the *Marginulina Bacheii*, B., *Textilaria Atlantica*, B., and other species characteristic of the soundings of the western Atlantic.

9. Examined by chromatic polarized light, the foraminiferous shells in these soundings showed beautiful colored crosses in their cells, and the mud accompanying them also became colored, showing that it is not an amorphous chemical precipitate. It in fact can be traced through fragments of various sizes, to the perfect shells of the Foraminiferæ.

10. In the vast amount of pelagic Foraminiferæ, and in the entire absence of sand, these soundings strikingly resemble the

chalk of England, as well as the calcareous marls of the Upper Missouri, and this would seem to indicate that these also were deep sea deposits. The cretaceous deposits of New Jersey present no resemblance to these soundings, and are doubtless littoral, as stated by Prof. H. D. Rogers (Proc. Bost. Soc. Nat. Hist. 1853, p. 297).*

11. The examination of a sounding 175 fathoms in depth, made in latitude 42° 53′ 30″ N., longitude 50° 05′ 45″ W. (near Bank of Newfoundland) by Lt. Berryman gave results singularly different from those above stated. It proved to be made up of quartzose sand, with a few particles of hornblende, and not a trace of any organic form could be detected in it. This exceptional result is important, as it proves that the distribution of the organic forms depends on something beside the depth of the water.

12. Connecting the results above mentioned with those furnished by the soundings made in the western portions of the Atlantic it appears that with the one exception above mentioned, the bottom of the North Atlantic Ocean, as far as examined, from the depth of about 60 fathoms, to that of more than two miles (2000 fathoms) is literally nothing but a mass of microscopic shells.

13. The examination of a large number of specimens of ocean water taken at different depths by Lt. Berryman at situations in close proximity to the places where the soundings were made, shows that even in the summer months when animal life is most abundant, neither the surface water, nor that of any depth collected, contained a trace of any *hard* shelled animalcules. The animals present, some of which are even now alive in the bottles, are all of a soft, perishable nature, leaving on their decay only a light flocculent matter, while the Foraminiferæ and Diatoms would have left their hard shells if they had been present.

As the species whose shells now compose the bottom of the Atlantic Ocean have not been found living in the surface waters, nor in shallow water along the shore, the question arises, Do they live on the bottom at the immense depths where they are found, or are they borne by submarine currents from their real habitat? Has the Gulf Stream any connection by means of its temperature or its current with their distribution? The determination of these and other important questions connected with this subject requires many additional observations to be made. It is hoped that the results already obtained will induce scientific commanders and travellers to spare no pains in collecting deep sea soundings. If such materials are sent either to Lt. Maury, U. S. Observatory, or to myself at West Point, N. Y., they will be thankfully received and carefully studied.

* See also this Journal, vol. xvii, p. 131.

ART. XV.—*On some New Localities of Fossil Diatomaceæ in California and Oregon;* by Prof. J. W. BAILEY, West Point, New York.

SOME interesting specimens of fossil Diatomaceæ from California and Oregon having come into my possession, I am induced to publish the following brief notices of them, in hopes to direct the attention of travellers in those regions to those remarkable deposits, and thus acquire more information concerning their position and extent.

1. The first specimen of fossil Diatomaceæ from California, I found among specimens of minerals collected two or three years ago in California by Washington Chilton, Esq., of New York. It was from *Suisun Bay*, 25 to 30 miles above St. Francisco, where Mr. Chilton says a large bed of similar material exists. It consists of a light white claylike substance made up entirely of fossil *marine* Diatoms, many species of which are identical with species occurring fossil in the tertiary diatomaceous deposits of Virginia and Maryland, while a number of the species found in these latter deposits do not occur in the California beds.

2. In a box of minerals collected in Oregon and California by Lt. Robt. Williamson, of the U. S. Topographical Engineers, I found four specimens of fossil diatomaceous earth, evidently from different localities, although unfortunately the precise locality is mentioned for but two of the specimens. I will designate them as specimens A, B, C, and D.

Specimen A.—This is a very light white substance, made up of the siliceous shells of *fluviatile* Diatoms. The predominant species are a small Gallionella, and a Discoplea mingled with a few species of Epithemia, Cocconema, Gomphonema and Spongiolites. This specimen was without a label, but is believed to be the specimen referred to in the following extract from a letter received from Lt. Williamson: "You will find some of the light white clay from *Pit River*, which I spoke of to you." This is, I believe, the same substance which has given rise to the newspaper accounts of cliffs in California composed of carbonate of magnesia.

Specimen B.—This is a light white chalky mass, whose locality is not given. It consists of fluviatile species, among which various species of *Biblarium* are quite abundant. The species of this genus have been found living in Siberia, and fossil in Oregon. Lt. Williamson's specimen resembles the Oregon mass found by the U. S. Exploring Expedition under Capt. Wilkes, but presents a different group of forms and therefore must be from a different locality.

Specimen C.—This is also a chalklike mass, whose precise locality is not marked. It is composed chiefly of a minute species of Gallionella, mingled with sieve-like discs which at first would be referred to the marine genus Coscinodiscus, but the entire absence of all other marine forms and the presence of several decidedly fluviatile species, makes me believe that the deposit is a fresh water one, and careful examination of these discs show that they are more nearly allied to the fresh water genus Stephanodiscus than to the marine Coscinodiscus.

Specimen D.—Is an ash-colored earth, marked as from near the Boiling Spring, Pit River. It is chiefly remarkable for containing a great number of Phytolitharia, or remains of the silíceous portions of plants, mingled however with numerous minute fluviatile Diatoms.

It is hoped that travellers in California and Oregon will keep a look out for specimens of light white clay like substances, and *carefully marking the locality at the time of collection*, send them to me for microscopic examination. Even a minute portion sent by mail will be very acceptable.

ART. XVI.—*Analysis of Beryl from Goshen, Massachusetts;* by Dr. J. W. MALLET.

THIS Beryl from Goshen is the variety formerly called Goshenite by Prof. C. U. Shepard, but which in his latest work, is referred to Beryl. The specimen examined was part of a broken six-sided prism, with rough faces of one inch or one and a half inches in diameter, having a very faint tinge of rose color. Sp. gr. = 2·813. It yielded on analysis,

Silica, - - - -	66·97
Alumina, - - - -	17·22
Glucina, - - - -	12·91
Peroxyd of iron, - - -	2·03
Oxyd of manganese, - -	*trace*
	99·13

which numbers are obviously those of Beryl.

Art. XVII.—*On the Silurian System of the Lake Superior Region;* by James Hall.*

Chazy, Birds-Eye, Black River, and Trenton Limestones.—These limestones are so intimately connected, one with another, in the Lake Superior district, and each is so thin, that no advantage can be derived from treating them separately. It is true, however, that each can be recognized as a distinct member of the lower Silurian series, and is characterized by fossils peculiar to itself, as has been shown in New York. Reduced as these formations are in thickness, it will, nevertheless, be necessary to study them separately, and for the geologist, or collector, to preserve the fossils distinct.

Commencing at the eastern limits of the district, these limestones are first seen upon the St. Mary's river; but they are better exposed upon the eastern side of St. Joseph's island, than upon the main land of the Michigan side. The sandstone, which is seen on Sugar island, plunges to the south, and passes beneath all these limestones, leaving, as far as observed, no trace of the calciferous; but an interval, covered by drift, occurs, where no rock is visible. In examining the shore of the island, the first rock seen, after the disappearance of the sandstone, is the Birds-eye limestone; but, further to the eastward, near a projecting point, some layers of the Chazy make their appearance, having, towards the bottom, an arenaceous character; while higher up, they assume an argillo-calcareous composition, and contain fossils characteristic of this member of the New York series. This limestone is also seen to pass directly beneath other beds, which, by their peculiar character, may be recognized as the Birds-eye. The fossils of the Chazy do not pass above the limits of the Birds-eye; but the respective limits of the two members are as well defined here as in any of their eastern localities.

The Birds-eye limestone is, for the most part, thin-bedded, the layers being separated by shaly matter, which rapidly wear away under the influence of the atmosphere and the water, while the harder parts are brittle and easily fractured. This limestone appears to be more fossiliferous here than in New York, and, in the upper layers particularly, we found a great number of Orthoceratites.

The Black-river limestone, or beds which may be regarded as the equivalent, seems to be intimately incorporated with the Birds-eye; so much so, that no line of demarcation could be detected.

* The following pages are cited from Chapters IX and X, of Messrs. Foster & Whitney's Report, on the Lake Superior Region, Part 2, and are in continuation of the part of the work from which we have cited on pages 11 to 33.

Further to the south, the Trenton limestone was observed extending in a low cliff, for some distance along the river, maintaining, to a great extent, the characters by which it is distinguished in more eastern localities. Its higher portions are made up, in a great degree, of crinoidal remains, and it preserves the same character as this portion of the series in the Mohawk and Black-river valleys. The whole mass is evidently much thinner than at any locality east of Lake Huron, and there is, also a larger proportion of shaly matter, not only between the layers, but incorporated in them.

In addition to the evidence derived from lithological characters, the fossil contents are of such a character, and so abundant, as to leave no doubt in this respect. The aspect not only of this member, but of the others, was such as to impress one with the belief that, though identical in age and in composition, and a continuation of their eastern equivalents, they were deposited under circumstances less favorable to organic life, resulting from the nature of the materials deposited, or from varying conditions in the ocean. The quantity of shaly materials mingled with this limestone, and distributed in layers between the beds, would seem to indicate that a shallow and turbid state of the water prevailed during its deposition.

The observations made by Messrs. Whittlesey and Desor, on the Manistee river, tend to confirm these views.

On the Escanāba river, for more than seventy miles along its meanders, above its mouth, these limestones are almost constantly exposed, and present these features. The river, for the distance of a mile before it enters the lake, flows over limestone strata, which are nearly horizontal, or dip very slightly in the direction of the current, but more gently than the descent of the water; consequently, the strata are cut through and their edges exposed, to the thickness of only a few feet. The first rock met with, in ascending the stream, is a tough limestone, in thin layers, separated by bands of shale. It has the lithological characters of the Birds-eye, and contains Orthoceratites and other fossils, characteristic of that member of the series, as well as of the Black-river limestone. The succeeding layers, which are well-exposed about a mile above this point, consist of thin, irregular, or wedge-shaped layers of light ash-colored limestone, verging to a dark-blue color, and contain many species of fossils, characteristic of the Trenton series; leaving no doubt of their identity. Many of the thin layers are composed of crinoidal remains, and the weathered surfaces are often completely studded with the detached joints or fragments of columns, standing in relief. This character of the weathered surfaces is unlike that exhibited in any part of this limestone noticed within the limits of New York; but an examination of these crinoidal fragments shows that they belong to genera, and, perhaps, species, known in this series elsewhere.

The thin and even-bedded layers at the mouth of the river, may be quarried to a considerable extent, whenever there shall exist a demand for them, and they will form a durable building material. The succeeding layers are too irregular to be of any value, except for burning into lime.

At the lower mill-dam, a mile above the first exposure, the banks of the stream, as well as the base of a small island, consist of beds of limestone, which form an escarpment fifteen feet thick. These also belong to the Trenton group, as indicated by the following fossils, which were collected at this point: *Isotelus gigas*, *Calymene Blumenbachii*, var. *senaria*, *Orthis testudinaria*, *Leptæna sericea*, and *L. alternata*.

In ascending the river, this limestone, and even the identical beds, continue as far as the Lower falls, distant two miles from the upper mill-dam. The stream for the most part is very rapid, and the dip of the strata very nearly corresponds with the descent.

At the Lower falls, the thin and irregularly stratified portions are succeeded by regularly-bedded strata of limestone, attaining a thickness of fifteen or twenty feet. It is impure from an admixture of arenaceous and argillaceous matter, while layers of these materials occur beneath. A few fossils were found at this place, among which were Brachiopods of the Trenton and Hudson river groups, with *Chætetes lycoperdon*.

After passing the falls, these last described beds very soon disappear, and there occurs an interval of several miles, where few traces of rock are observed; but, at several points, the limestone is seen by the margin of the river,—the descent of which is here very gentle,—in no instance exposed to a greater thickness than two feet. The layers are thin, of a light-grey color, of a granular structure, and contain numerous cavities, some of which are partially lined with crystals. Although these few beds of themselves are of little importance; yet, when studied in connection with the range of the series, they present a feature of considerable interest, noticed here for the first time. These compact, grey beds lie above the limestone seen at the Lower falls, since they clearly pass beneath the channel of the river, before the others emerge. Between the Lower falls and the Meadow,* distant

* This is a somewhat remarkable feature in a river of this character, where the general descent is very rapid, being some seven or eight hundred feet in the distance of thirty miles. The principal meadow is found at a bend in the river, the ordinary channel just above it turning abruptly to the east, and making a broad curve, where it has cut through the drift; while to the west is another channel, through which a part of the water is discharged during freshets, uniting with the main channel half a mile below; thus leaving on the west side a large tract of bottom-land, the upper extremity of which consists of a wooded island. In looking from the eastern bank, a broad meadow bounds this temporary channel, flanked on the right by the wooded island, and on the left by the unbroken forest. In this meadow are several elms of magnificent size, the nearest ones standing out in bold relief, while the farthest blend with the forest growth of maples, beaches, &c. Their mode of growth shows that,

nine miles from the lake, the surface is mainly covered by an accumulation of boulders, apparently derived from the drift, which forms a steep escarpment on the eastern side of the river. Below this place, the river curves to the eastward, cutting deeply into an accumulation of this character; but, above, it again bends to the westward, and lays bare, on the east side, a ledge, some twelve feet thick, of grey limestone, thin-bedded, and containing small cavities, sometimes lined with crystals of magnesian carbonate of lime, and at others empty. These layers are a continuation of those before described as occurring at the water's edge, several miles below.

From this point, onward, for a considerable distance, the dip of the strata is more rapid than the descent of the stream, though the latter is quite rapid; consequently, there is a succession of the lower strata presented to view in its banks. I had, therefore, an opportunity of verifying my first observations, that the grey, granular limestone rested upon some shaly and arenaceous beds with thicker calcareous strata, like those seen at the Lower falls, succeeded by the irregularly stratified beds observed at the upper mill-dam. We had an opportunity of tracing these two last divisions for several miles along the river, where these escarpments were exposed from twenty-five to thirty feet in thickness, disclosing, in the ascending order, the Birds-eye limestone, succeeded by the Trenton, with scarcely a trace of the Black river limestone; for, while the *Ormoceras*, characteristic of the latter rock, occurs at the junction of the other two, in the same connection is found the *Orthoceras multicameratum*. Notwithstanding, therefore, the extreme tenuity of these different members, and the great admixture of arenaceous and shaly matter, there is no difficulty in recognizing, at this remote point, the important subdivisions which have been made in New York, and of determining them by their characteristic fossils.

From the first exposure of the rocks above the meadow, they are almost constantly in view to the Upper falls, and from thence, onward to the forks of the river. About two miles from the upper end of the meadow, the Birds-eye limestone is seen at the level of the river and continues, with some slight undulations, to occupy the surface, as far as the first rapids below the Upper falls. At Indian creek, a short distance below the foot of the rapids, the Birds-eye limestone is very distinctly defined, and rests upon some heavy beds, which clearly represent the Chazy limestone. One of these beds is remarkable for weathering in a peculiar manner, and an examination shows that it is filled with a kind of

from their commencement, which is very ancient—since two or three were observed which had fallen from age—they had stood in the open areas which they now occupy. In such wooded bottom-lands, in this latitude, we often find plants and trees flourishing luxuriantly, which, under ordinary circumstances, are found only in more southern situations.

tough, silicious and irregularly-shaped concretions, or segregations, which stand out in relief, while the calcareous part wastes away.

At the Upper falls, the strata rise more rapidly to the northward, and though the ascent of the stream is considerable, yet, on arriving at the foot, the calciferous sandstone is exposed, forming the base of the escarpment over which the water is precipitated; while, above it, there are two layers which represent the Chazy and Birds-eye limestones and the lower part of the Trenton group.

Here, the following section is exposed in an ascending order.

1. Birds-eye limestone, fine-grained and compact, of a bluish-drab color.
2. Calcareous layers, of a grey color, with crinoidal joints and other fossils,—4 feet.
3. A heavy-bedded, variegated limestone, with much silicious matter, the surface weathering very unevenly,—2 feet.
4. A thick, silico-calcareous bed, with fossils in the upper part, —2 feet.
5. Silico-calcareous layers at the foot of the falls, thin and even-bedded,—1 foot.

The whole exposure at the falls is about fifteen feet, and in the bank above, about ten feet more. The beds forming the top of the falls disappear below the river, near the point where Indian creek comes in from the east. The layers having the character of the Birds-eye limestone disappear a short distance below, and are succeeded by thin beds containing an abundance of *Orthis testudinaria*, *Leptæna sericea*, and *L. alternata*, with other fossils of the Trenton limestone, and have the same character as some of the layers about midway in this group, as developed in the Mohawk and Black river valleys, in New York. Above the falls, the low cliff of fossiliferous limestone continues for some distance, gradually declining to two or three feet in height above the river. The same changes take place, with the recurrence of the same layers, in ascending the stream, the strata rising more rapidly than the ascent of its bed. From this cause, we find the calciferous sandstone coming out from beneath the fossiliferous limestones, at a point some three miles above the falls, and continuing thence up the stream for the distance of two miles above its forks.

These limestones, which have a combined thickness of less than seventy-five feet, are exposed almost continuously in the bed and banks of the stream, for the distance of more than thirty miles, following its meanders, and a distance of about twenty miles in a direct line. The difference between the dip of the rock and the descent of the river, is less than sixty feet. There is, however, very little parallelism between the two; for, within

the first eight miles after leaving the lake, we meet with the highest beds of limestone in the series which occur on this river. Although its descent is rapid, yet it is unequal in its rate, and these inequalities appear to be due to undulations in the strata, which can be detected at several points. For the most part, the stream is very shallow, and its bed rocky.*

Along the whole extent of this exposure of the rocks, whether examined continuously, or at intervals, there is no difficulty in identifying different portions with their New York equivalents. When taken as a whole, and all of the beds examined in connection, the principal subdivisions, such as the Chazy, Birds-eye, and Trenton limestones, are readily identified, not only by their lithological characters, but by their organic remains. Even in the arenaceous layers, which form some twenty feet of the whole thickness, we not only detect numerous species of fossils peculiar to the Trenton limestone, but many peculiarities of bedding, and other characteristics, which, though not easily described, are readily understood and comprehended by the geologist.

It is deemed unnecessary to give farther details of the variable features of these limestones along the Escanāba river; in all the localities examined, they offer little of economical value, aside from their application to building purposes.

At the mouth of Rapid river and along its borders, and also at the mouth of the White-fish and the head of Little Bay des Noquets, the Trenton limestone is exposed, exhibiting the same lithological characters, as at the upper dam on the Escanāba.

Farther explorations made by Mr. Whitney, along the White-fish river, in crossing from Little Bay des Noquets to Lake Superior, proved the occurrence of the Trenton group, for the distance of fifteen miles, or more, from the head of the bay. The specimens procured are filled with fossils, principally *Leptæna sericea*, and occasionally with *L. alternata* and *Orthis testudinaria*, while, in lithological characters, they agree with those observed on the Escanāba and Manistee. The country along the White-fish river is low, rising little above the river margin; consequently, there are no cliffs, or escarpments, where the strata are exposed to any extent, and specimens can be procured only at the water's edge. This river then, like the Manistee, affords evidence of the existence of certain groups, but does not admit of continuous observation as to their succession, thickness, and importance.

* The name Escanāba signifies *Smooth Rock*, given for the reason that the stream often flows for considerable distances, over the smooth surfaces of the slightly inclined rocks. The inequalities caused by the offset of particular beds, give rise to numerous rapids, and render the navigation so difficult that even a small skiff cannot be impelled against the stream, when the water is low, except by using setting-poles armed with steel points.

In the present state of the northern peninsula, being almost an unbroken wilderness, and the elevation of the country occupied by the Silurian series but a few hundred feet above the lake, with no abrupt curves in the strata, by which they are brought to the surface, it is impossible to determine anything more than the limits of the more important groups: for all practical purposes, however, the determinations already made are sufficient; and it was only with the hope of acquiring more detailed information, that we desired more time and better opportunities of investigation.

Leaving the Escanāba, and following along the coast of the bay in a southeasterly direction, we soon find the limestones, just described, coming out to the surface at the lake-level and scarcely rising above it, the character of the beds being the same as those seen within a mile of the mouth of the river.

At the mouth of Ford river, the country is low and there are no rocks visible. The banks consist of alluvial, or drift materials, for four miles, when there occurs a long rapid over the thin-bedded limestone, the same in character as that at the upper mill-dam on the Escanāba. Proceeding towards Cedar river, we passed several reefs of rock and observed large slabs of limestone in the shallow water, which appeared identical with those at the mouth of the Escanāba, and lower than the thin-bedded portion of the Trenton group. Upon Cedar river, there are no rocks visible for two miles after leaving its mouth; but here, at the end of a mill-dam, the arenaceous and shaly bands, which occur at the Lower falls of the Escanāba and opposite "Wood's Camp," are visible. These occupy a higher position in the series than those seen at Ford river. Few fossils were here observed, crinoidal joints being the most numerous.

From the mouth of Cedar river to the mouth of the Menomonee, the more thickly-bedded portions of the Trenton, with layers of Birds-eye, occur along the margin of the bay. Although nearly in situ, the beds have been raised and broken by the water, and, in some places, piled up in walls, or barriers, which have a very artificial appearance.

At the lower dam, on the Menomonee, a little above the water, limestone is observed, in places, on the right bank, its surface being ground down, and grooved with drift-scratches. Its character is very similar to that of the Birds-eye, and the only fossils observed were crinoidal joints.

The west side of Green bay, from the mouth of the Menomonee to its head, was explored by Messrs. Whittlesey and Desor. The specimens collected showed a continuation of the same limestones which had been observed from Little Bay des Noquets to the Menomonee. The fossils collected were two species of *Murchisonia*, *Pleurotomaria lenticularis*, and several *Brachiopoda*.

After examining the eastern shore of Green Bay, I took up my observations upon the same limestones at Depere, tracing them along the Fox river to the outlet of Lake Winnebago. Subsequently, in order to connect the geology of the Lake Superior district with that of the Chippewa district, I continued my examinations across the state of Wisconsin to the Mississippi river, and thence, at intervals, along that river to the falls of St. Anthony. At Mineral Point, the lower members of the series have become very argillaceous, weathering into a light drab color, and are characterized by numerous fossils. At Plattsville, the Birds-eye layers are pretty well defined, though associated with much shaly matter and some layers of dark shale. The rock, on being freshly fractured, is very dark-colored, but weathers to an ashen hue. The Trenton limestone, which succeeds, is thin-bedded and light-colored, and all that remains is scarcely more than twenty-five feet in thickness. The same features are observed at Galena, and again at Dubuque. At the latter place, the connection of this group with the succeeding limestone is very obvious. In all these localities, the entire thickness of these lower limestones, which can clearly be identified with the Trenton and associated limestones of the east, is less than fifty feet; but it is possible that some better exposures would give a greater thickness.

I conceive that there can be no longer a doubt in reference to the age of the limestones under consideration. Their identity with those of New York and of Canada has been established, not only by a comparison of the fossils, but also by tracing almost continuously their range from the Mohawk, Champlain, and Black-river valleys, through Canada, to the eastern limits of this district, and thence westward, continuously, to the Mississippi river.

These remarks also apply to other groups, concerning which some difference of opinion has heretofore prevailed. Feeling the necessity of adopting some recognized standard, we have referred these subdivisions, so well marked, to those which have already been made by the New York geologists.

Before leaving the subject of these limestones, it will be necessary to recall to mind some observations made on the Escanāba river, above the Lower falls, and at the bend above the Meadow. The upper layers of grey limestone, at the last named point, have a thickness of some fifteen feet, are meagre in fossils, and do not appear to be identical with any portion of the series, which I have observed farther east. In going westward, I had not an opportunity of observing the overlying deposits of the Trenton limestone until I arrived in Wisconsin. Here, in numerous localities, as well as in Illinois and Iowa, the deposit above that which is marked by an abundance of fossils characteristic of the Trenton, is a grey, or drab-colored limestone, and very friable, forming

a part of the "cliff limestone" of the Ohio and Indiana reports, and is called by Dr. Owen, in his report on the Lead region, the "upper magnesian limestone." From its position, as well as its lithological characters, it appears that this limestone, which is the principal lead-bearing rock in these states, is a continuation of that noticed on the Escanāba, lying above the fossiliferous beds of the Trenton limestone; but that it has increased in thickness, as traced westwardly, and becomes an important member of the series; and hence, we have designated it in the classification of the rocks, as the "Galena limestone."

In the neighborhood of Galena, Dubuque, Mineral Point, and other places, there are numerous localities where a direct succession in the beds may be traced. It is very evident that this limestone diminishes in thickness eastwardly from these points, and becomes a very subordinate member of the series, losing, at the same time, its metalliferous character. From the general absence of fossils, and from its resemblance to the next succeeding limestone in lithological character, no distinction has usually been made between them. In the localities cited, particularly in the neighborhood of Dubuque, the higher grounds are occupied by a limestone containing an abundance of *Catenipora*, *Heliolites*, and other corals marking it as of the age of the Niagara. From the relative position of these coral-bearing rocks to the lead-bearing strata, it has been inferred that they were but parts of the same group, and they have heretofore been described as such.

This was the state of our knowledge, when I examined this series in 1841, and having satisfied myself that the coral-bearing limestone of Wisconsin and Iowa could be clearly identified with the Niagara group of New York, I expressed the opinion that the lower part of the cliff limestone was of the same age. Up to the present time (1850) I am not aware of any published evidence from an examination of the rock in place, to prove that the lead-bearing rock is of lower Silurian age.* The principal fossil resembles a *Coscinopora*, but is probably a *Receptaculites*. I have found, however, in the same rock, the head of an *Illænus*, a *Leptæna*, not unlike *L. alternata*, *Spirifer lynx*, and *Atrypa increbescens*. The still higher, thin-bedded, argillaceous limestone contains a species of *Lingula*, undistinguishable from *L. subquadrata*, *Spirifer lynx*, *Pleurotomaria lenticularis*, *Murchi-*

* Mr. Conrad, in the proceedings of the Academy of Natural Sciences of Philadelphia, 1843, expressed his opinion that the lead-bearing limestone was of the age of the Trenton, from certain fossils obtained at Mineral Point. These fossils are from the Trenton limestone proper, but no productive veins are known to occur in that rock so far as I can learn. Dr. Owen in his [earlier] report upon that region remarked that the veins die out on reaching the "blue limestone." This blue limestone, in Wisconsin, is no other than the Trenton limestone containing large numbers of the fossils peculiar to that rock, and underlying the blue marl and limestone of Cincinnati and other western localities, and which are not recognized in central and western Wisconsin.

sonia bellicincta, and another species with angular volutions, a large *Orthoceras*, and fragments of *Illænus*. Up to this point, I found no corals of the Niagara period, and though the fossils are not numerous, they are all of lower Silurian forms, and furnish the best evidence we have of the age of this limestone.

This lead-bearing rock, as before observed, rests upon fossiliferous strata of the Trenton age, which can be recognized as the identical group traced over several hundred miles. The galena sometimes penetrates the Trenton series, in films or sheets, but does not form veins, as in the grey, heavy-bedded limestone above.

From all the evidence, therefore, the lead-bearing, or Galena limestone, must be regarded as a distinct member of the lower Silurian system, which is not recognized at the east. From its gradual diminution in thickness, its source appears to have been towards the west. The conditions of the ocean, though favorable to the deposition of this immense mass of calcareous materials, were unfavorable to the development of organic life; for, although there remain a few species which continue through the period of its deposition, the greater number known in the group below did not survive beyond the commencement of this. The occurrence of more highly fossiliferous strata above, still of lower Silurian age, would show that the Galena limestone does not form a series of transition beds between the upper and lower Silurian.

To the south and southwest, this rock is of limited extent, probably nearly coincident with the lead region; the universal testimony showing that no productive lead mines exist in the western states, out of the range of this rock.

This fact sets at rest all speculations as to the probable metalliferous character of certain rocks which have been supposed to be identical with the Galena limestone. The lead-bearing rock is a peculiar one, holding a certain place in the series, and of limited geographical extent. It is metalliferous throughout the greater part of its known limits, where it has considerable thickness. The lead veins are almost wholly confined to it, and evidently have their source in it. The small quantities sometimes found below its base are in seams that die out, as they penetrate the inferior rock, and it often takes the form of interlaminations among the strata, having little connection with the lower masses.

Regarding the higher beds before alluded to as identical with the Galena limestone, it is not probable that the rock contains any valuable deposits of ore within the Lake Superior district; but, on the other hand, the small thickness of the mass would preclude the possibility of the occurrence of valuable veins. The fact of the existence of this rock, as a distinct member of the series, is interesting in a geological point of view, and opens the question as to the completeness of the series, which has been studied in New York, Canada, Pennsylvania and Virginia.

There is another question which may arise, and that is, as to the relations of the lead-bearing rock to the Hudson river group; for there appears to be little probability of identifying this group, at any of the localities west of Lake Michigan. If the upper, ash-colored beds on the Escanāba are identical with the Galena limestone, there is then no difficulty in determining the question; for the Hudson river group is superior to this limestone. Although I am not aware that the shales of this group have been recognized in Wisconsin, or Iowa, I am disposed to believe that the numerous fossils found in the drift,—among which are a small *Nucula*, *a Cleidophorus*, *Pleurotomaria*, and others,—are derived from the destruction of beds of that age, which lie above the Galena limestone. This opinion is further strengthened from having found on Little Bay des Noquets some beds filled with small fossils similar to those noticed; and I have received a specimen of similar character, said to have been procured, in place, near Galena.

[Mr. Hall next describes the Upper Silurian and Devonian Series, showing that the region presents strata of the Clinton Group, Niagara Group, Onondaga Salt Group and upper Helderberg Series. The Medina Sandstone which occurs below the Clinton Group was not recognized. The Clinton Group occurs at Drummond's Island, along the eastern shore of Green Bay, on Sturgeon Bay, and probably about Lake Winnebago. To the southwest of Green Bay near Hartford, there is a band of oolitic argillaceous iron ore, similar to that of the Clinton Group in New York. Beyond the entrance to the Bay des Noquets, fossils of a species of Cytherina, an Avicula and Murchisonia subulata were observed; and at Sturgeon Bay, the Pentamerus oblongus. The Clinton Group becomes calcareous to the west; while in central New York it consists mainly of shaly and arenaceous beds, with very subordinate layers of calcareous matter, at the Niagara river it is made up of two members of limestone and one of shale.

In closing his remarks on the Niagara Group, Mr. Hall observes]:—

Notwithstanding all the changes which have taken place in the Niagara group, as developed at different points, and its intimate blending, as in this district, with the limestone of the Clinton group below and the Onondaga salt group above, we find no serious difficulty in recognizing it as a whole, both by lithological characters and fossil remains. We have been able, by these characters combined, to trace its continuation throughout the entire district from east to west. We have seen it, in this extent, assuming different aspects, dependent on causes before adverted to; but we have never failed to find a greater or less number of known characteristic fossils, even where the strata were explored only to a limited extent. Their occurrence, under such circum-

stances, and their persistence over so great an area, where physical characters have in a great degree failed, only serve to demonstrate the value of these means of studying and identifying the stratified deposits.

I have, also, had an opportunity of tracing this group, at intervals, across the country between Lake Michigan and the Mississippi river, and of recognizing it by its fossils, particularly its corals, even beyond that point, to the southwest. It exists in Ohio, Indiana, Kentucky, and Tennessee, and may be recognized, not only by its lithological characters, but by its numerous fossils, identical with those first described in the New York Geological Reports, as occurring in this group. Among these, we have, in addition to the corals, which are the more common fossils, several species of crinoids, the *Caryocrinus*, *Eucalyptocrinus*, *Ichthyocrinus*, and others which are identical with species known to occur in New York.

In a southwesterly direction, and without the limits of this district, this group has been examined by Mr. I. A. Lapham, of Milwaukee, who has had no difficulty in recognizing it by its characteristic fossils. His observations will be found incorporated in the subsequent pages of this report.

Thickness of the Niagara and Clinton Groups.—As already remarked in the commencement of this chapter, the lowest beds are seen at the lake-level on the eastern side of Drummond's island; while on the northern side, we find the higher beds of the Hudson-river group. Again, on the St. Mary's river, the lowest beds of the Clinton group come to the water-level just above Lime island. Passing westward, along the northern shore of Lake Michigan, although numerous undulations are visible, often enabling the observer to see a considerable thickness of strata, yet the lower beds are nowhere exposed, until we arrive at the bluffs on Big Bay des Noquets. I have already mentioned the exposure of the same beds here which we had seen on Drummond's island. The entire height of the cliffs does not exceed two hundred and fifty feet, and we have nowhere evidence of the existence of superior beds of more than one hundred feet in thickness belonging to these groups. The entire thickness, therefore, of the calcareous beds of the Niagara and Clinton groups does not exceed three hundred and fifty feet. This is, I am aware, somewhat less than the estimate of Mr. Murray, in his section across the Grand Manitoulin islands, which, including both groups, amounts to five hundred and sixty feet.* Although there are, at intervals, exposures which appear along the coast, where the rate of dip is such as to give a greater estimated thickness than three hundred and fifty feet, yet we have no positive proof of a greater observed thickness.

* Geological Survey of Canada, Report of Progress, 1847–48.

In this estimate, it must be understood that the elevated portions of the island and peninsula of Mackinac are not included, for they are occupied only to a small extent, if at all, by strata of this age.

[The Onondaga Salt Group occurs at Mackinac and St. Ignace, but only in thin beds, having diminished in thickness to the west. North of St. Ignace Mr. Whittlesey found a marly bed about 50 feet thick, containing gypsum in isolated masses occurring under the same forms as in New York and Canada West. This marly bed with some higher and more calcareous ones, represent the Onondaga salt group. This bed is not recognized along Green Bay or at Milwaukee, and has probably entirely thinned out.

The Upper Helderberg series, including the Schoharie grit, the Onondaga and Corniferous limestone, is largely represented in the west, though those subordinate groups cannot always be made out. The series, like others, is marked by an increase of calcareous matter on passing westward. The limestones have been greatly worn or denuded, and upright or overhanging cliffs, tower rocks, and domes, are of frequent occurrence about the islands and peninsula of Mackinac. Mr. Hall closes with the following observations on the Fossils of the bed]:—

So far as I observed, the island of Mackinac and the adjoining coast, furnish few of the larger corals, though Favosites and many species of Cyathophillidæ are common. Farther south, however, in the neighborhood of Presq'isle, on the western shore of Lake Huron, where the upper beds of this group come to the level of the water, the corals largely predominate, and the conditions of the ocean appear to have been highly favorable to their growth and development.

In collecting fossils about this island, one is liable to be deceived in regard to the character of the rocks, since it often happens that those of the Niagara group have found their way among the loose materials which have been transported from the northern shore. Thus, the *Catenipora*, *Heliolites*, and other corals of the Niagara group may be picked up at the base of these cliffs, associated with those which have fallen from the cliffs above. As a general remark, however, it may be stated that the fossils of the Niagara are much oftener silicified than those of the group under consideration. Owing to this fact, it might readily be inferred, without careful comparison, that the Niagara group existed on the island of Mackinac and on the peninsula to the northwest. Notwithstanding, however, the great similarity in aspect and color, they are very different in their chemical composition and their associated organic remains.

Most of the fossils collected at Mackinac prove to be undescribed, but are identical, however, with species which occur in the same rocks in New York. Some of the smaller bryozöoid

corals belong to the genus *Trematopora* and *Cladopora*, while two or more species of *Favosites* were observed. A few shells only were collected, and these, with a single exception, belong to the *Brachiopoda*. Among the trilobites was a *Phacops*, resembling *P. bufo* and a species of *Proetus*, both apparently identical with species which occur in the upper Helderberg range. One of the most characteristic species, however, is the *Phacops anchiops*, characteristic of the Schoharie grit. The specimens of the latter fossil, though consisting only of portions of two bucklers, are so peculiarly characteristic, that I cannot doubt the identity in age of these widely-separated localities. Although it would have been desirable to identify a larger number of fossils with those occurring in the corresponding series elsewhere, yet the evidence is sufficient to remove this group from any below the Oriskany sandstone.

ART. XVIII.—*On the Theoretical Relations of Water and Hydrogen;* by T. S. HUNT, Chemist to the Geological Commission of Canada.

IN carrying out his theory of types, M. Laurent proposed to consider water H_2O_2, having its equivalent represented by four volumes of vapor, as the type of the oxyds like M_2O_2, of the hydroxyds $(MH)O_2$, and of the sulphurets corresponding to these two classes. By his system of compound radicals, Liebig had extended to organic chemistry the nomenclature of Lavoisier, and he looked upon spirit of wine $C_4H_6O_2$, as the hydrated oxyd of a radical ethyl $(C_4H_5 = Et)$, while hydric ether C_4H_5O, was the simple oxyd of the same radical. But as ether-vapor contains in the same volume, twice as much carbon as the vapor of alcohol, Gerhardt had already proposed to double the formula of ether, and Laurent now showed that while alcohol is to be regarded as the hydroxyd of ethyl $(EtH)O_2$, or water in which ethyl replaces an equivalent of hydrogen, ether is the anhydrous oxyd, in which the second equivalent of hydrogen is replaced, and should be written Et_2O_2. Hence while ether is neutral, alcohol is monobasic, having an equivalent of hydrogen replaceable by a metal, and is the type of monobasic vinic acids, while water is the type of bibasic acids. (*Laurent, Récherches sur les Combinaisons azotées. Ann. de Chim. et de Phys., Nov.* 1846.)

In a review of that remarkable essay, published in this Journal for Sept., 1848 (vol. vi, p. 173), I suggested that this view was "susceptible of still farther extension, and that we may include in the same type all those saline combinations (acids) *which contain oxygen*." I referred to the hypochlorites ClO, MO, as derivatives of the type H_2O_2, in which Cl replaces H; being $(ClH)O_2$,

and $(Cl\,M)O_2$, while anhydrous hypochlorous acid is Cl_2O_2, the result of a complete substitution. "In the same manner nitric acid, $N\,HO_3$, is a monobasic salt (i. e. acid), corresponding to water in which NO_2 is substituted for H, as in many organic compounds; we have then $(NO_2, H)O$ and $(NO_2, M)O$;" or $(NO_4, H)O_2$ in the notation adopted above. "As an adaptation of this idea to bibasic compounds, sulphuric acid, $S\,H_2O_4$, is to be regarded as water in which $S\,HO_3$ replaces H; thus $(S\,HO_3, H)O$. As the replacing elements contain an equivalent of hydrogen which is saline (i. e. replaceable by a metal), the acid is bibasic. When the hydrogen in $S\,HO_3$ is replaced by a metal, we have a class of acid sulphates like $(S\,KO_3, H)O$. The complete replacement of hydrogen in the original type yields $(S\,HO_3)_2O$, which is the Nordhausen acid commonly represented by $2SO_3$, H_2O. This latter compound as Gerhardt has shown, corresponds to the anhydrous bisulphate of potash."

"The tribasic acids may equally be reduced to the same type, if we conceive the elements which replace one equivalent of hydrogen, to be bibasic instead of neutral or monobasic; phosphoric acid, $P\,H_3O_4$ is $(P\,H_2O_3, H)O$."

"The primitive saline type is then essentially bibasic, and is presented in its most elemental form in water, while the simplest type of the monobasic salt, which is a derivative of the last, is found in hypochlorous acid." p. 174. This view of the derivation of polybasic acids is illustrated by the bibasic sulphacetic, and the tribasic sulphosuccinic acid.

On page 177 we further remark, that "the binary molecule of the metals, hydrogen, chlorine, bromine, etc. will be seen to be the type of an immense number of combinations, embracing the various alloys and amalgams, the hydracids like hydrochloric acid, with their corresponding salts, and such compounds as Cl Br and Cl I, while $I\,Cl_3$ is referable to a triple molecule of these elements, represented by H_6; to this type belong the perchlorids of antimony, arsenic and phosphorus, while the corresponding trichlorids form a double molecule."

In a subsequent Essay on Chemical Classification read before the American Association for the Advancement of Science, at Philadelphia, in September, 1848, and published in this Journal for May and July, 1849, (vols. vii and viii,) we observed that the relation between alcohol and acetene is that which subsists between the two types H_2O_2, and H_2, acetene being hydrogen in which ethyle replaces H, thus $C_4H_5, H = C_4H_6$, while hydrochloric ether is a chlorinized hydrocarbon corresponding to hydrochloric acid, so that having repeated what has been already cited as to the type H_2, we add, "moreover it follows from the relations of H Cl to the chlorinized hydrocarbons, that it (H_2) is the type of all the hydrocarbons, as well as of the alkaloids

which may be described as amidized species of them, and are equally susceptible of substitutions by chlorine." It was also remarked that "as many neutral oxygenized compounds, which do not possess the saline character, are still derivatives of acids which are referable to the type H_2O_2, we may regard all oxygenized bodies as belonging to this type." "While nitric acid is $N HO_3$, or $(NO_2,H)O$, the result of the complete replacement of H by NO_2 will be $(NO_2)_2O$, or the unknown dry nitric acid, homologue of the so-called anhydrous phosphoric and arsenic acids, which are equally $(PO_2)_2O$, etc." Vol. viii, p. 92.

One of the objects proposed in the essay just quoted, was a comparison of the views of Gerhardt and Liebig with regard to the formation of ethers, amids, and allied bodies. Gerhardt in accordance with the electro-chemical theory of Berzelius, had considered the acids in these reactions to be electro-negative by their oxygen, while the alcohols, ammonia, and the hydrocarbons were electro-positive by their hydrogen, so that these bodies *minus* H_2, replaced O_2 in the acid.* To this view we objected that it leaves unexplained that change in the basic relations of the acid, which Liebig rightly understood when he compared the ethers to salts, and represented the acid as losing H, which is replaced by the elements of the alcohol *minus* HO_2. This theory, unlike that of Gerhardt, made the ethers of the hydracids enter into the same class with those of the oxacids; at the same time it did not include those bodies which are produced with the elimination of H_2O_2, by the action of oxygen acids upon ammonia and hydrocarbons, and which were recognized in Gerhardt's system, as completely analogous to the ethers in the mode of their formation. Here the compound radical theory is found to be defective, although the analogy which forms its point of departure is correct. In concluding this comparison we remarked that "we are led to recognize the view of Liebig, *apart from his ideas of dualism, and his theory of compound radicals*, as the one fundamentally true." (Vol. vii, p. 405).

In this Journal for March, 1848, (vol. v, p. 265,) we observed that the relation of wood-spirit to acetonitryl is the same as that of water to hydrocyanic acid, and that water differs from wood-spirit, precisely as this last differs from spirit of wine, so that the relation of homology, recognized by Gerhardt in the compounds of carbon, is extended to water and hydrogen; for from the relations which we have asserted between H_2O_2, and H_2, it follows that while water is the homologue of the alcohols, hydrogen H_2 is the homologue of acetene C_4H_6, $(Et H_2)$ and of formene C_2H_4, $(Me H)$ which Frankland calls hydrids of ethyl and methyl, as well as of his zinco-methyl C_2H_3, Zn. The bodies which he regards as the alcohol radicals are still homologues of

* Précis de Chimie Organique, tom. ii, p. 495.

hydrogen, the result of a complete substitution, and are $(C_2H_3)_2$ etc., like benzile $C_{28}H_{12}O_4$, which is Bz_2, while bitter-almond oil is Bz H.

In the Journal for January, 1850 (vol. ix, p. 65), this is again referred to, and we remark that as water is to be regarded as the homologue of the alcohols, it follows from the principles already laid down "that the ethers are homologous with their parent acids," a point which was illustrated by the action of the cyanic ethers with ammonia; while the volatile bases of Wurtz "sustain to their corresponding alcohols, the same relation that ammonia does to water." In volume xiii, p. 206, we repeat, "water is not only the analogue, but the strict homologue of the alcohols, so that the molecule H_2 is the equivalent (homologue) of C_4H_6, and its homologues, and H of ethyl and methyl; (the hypothetical radicals.)"

The question whether these homologues of hydrogen H_2 are to be regarded as the radicals of the alcohols and ethers, has been discussed by Gerhardt, Hofmann, and others, but resolves itself into this; Frankland's ethyl is to Et Cl what Zn_2 is to Zn Cl, and H_2 to H Cl; the metals, hydrogen and chlorine always present a dualism in their reactions, as marked as ethyl, kakodyl and cyanogen.

Williamson (*Philos. Mag., Nov.*, 1850,) has made a beautiful application of Laurent's theory of the alcohols; by the action of potassic alcohol $(Et\,K)O_2$ upon hydriodic ether, Et I, he obtained K I, and Et_2O_2, and by a similar process mixed ethers, such as $(Et\,Me)O_2$. He at the same time explained the theory of the ordinary ether process, as the reaction between sulphovinic acid, $S_2(Et\,H)O_8$, and $(Et\,H)O_2$, giving $S_2H_2O_8$, and Et_2O_2. Meanwhile Chancel, following out the same idea, announced almost simultaneously with Williamson, the production of hydric ether by the distillation of sulphovinate of potash with potassic alcohol; by the reaction of oxalovinate with sulphomethylate of potash, he also obtained a mixed oxalic ether $C_4(Et\,Me)O_8$, oxalic acid being $C_4H_2O_8$.

Still more recently Gerhardt has announced the production of a class of bodies, which he describes as the anhydrids of the monobasic organic acids. He had formerly regarded the production of anhydrids as characteristic of polybasic acids, because he would not admit the theoretical derivation of monobasic acids from a bibasic type H_2O_2, the complete replacement of whose hydrogen should, as I have long ago shown, yield neutral anhydrids, (like the anhydrous nitric acid since discovered,) sustaining to the corresponding acids the relation of hydric ether to alcohol. According to the view which I advanced in 1848, acetic acid, $C_4H_4O_4$, was represented by $(C_4H_3O_2,H)O_2$, and the anhydrid would be $(C_4H_3O_2)_2O_2=C_8H_6O_6$, corresponding to four vol-

umes of vapor. This body has been obtained by Gerhardt as well as the butyric, valeric, benzoic, and cinnamic anhydrids, besides mixed species analogous to the mixed ethers, such as the aceto-benzoic anhydrid, which contains the elements of one equivalent each of acetic and benzoic acids, *minus* H_2O_2. These bodies are of course neutral, and regenerate acids by assimilating the elements of water.

The process by which these bodies are obtained, is very instructive: when the perchlorid of phosphorus PCl_5, or the oxychlorid PO_2Cl_3 acts upon a salt like the acetate of potash, a body represented by $C_4H_3ClO_2$ is obtained, which bears the same relation to acetic acid that hydrochloric ether does to alcohol; by the action of this acetic chlorid upon acetate of potash, chlorid of potassium and anhydrous acetic acid are produced. Alcohol $C_4H_6O_2$ being represented as $(Et\,H)O_2$, we may write the formula of acetic acid $(Ac\,H)O_2$, $(C_4H_3O_2 = Ac)$, while the chlorid is $Ac\,Cl$. This corresponds to hydrochloric or hydriodic ether, while acetate of potash $(Ac\,K)O_2$, is analogous to potassic alcohol. The process is then similar to that by which Williamson obtained hydric ether; $Ac\,Cl + (Ac\,K)O_2 = K\,Cl + Ac_2O_2$, or the anhydrous acid.

The reaction in all these cases is, as I have pointed out in the paper before quoted, (vol. viii, p. 93) identical in essence with that between $H\,Cl$ and $(K\,H)O_2$, yielding an alkaline chlorid $K\,Cl$, and water H_2O_2, the prototype of all the above acids, ethers, alcohols, and anhydrids. We have there also remarked that H_2O_2 is to be regarded as a derivative of hydrogen, H_2, and that it is often difficult to distinguish between the types. Thus, for example, the acetic chlorid might be regarded as a chlorinized aldehyde, $(C_4H_3,Cl)O_2$, belonging to the second type, while its reactions permit us to compare it with the hydrochloric ethers of the type H_2. It must be kept in mind that although the apparent dualism deduced from the results of chemical change, is subject to but very simple variations in the elements, it is exhibited in so many different ways in the higher species, that we cannot assign an absolute value to any hypotheses based upon their changes.

I have been particular in again bringing forward these views, because they now belong to the history of chemical theory, and because after having maintained them alone since 1848, and having insisted upon them in various ways in my communications to this Journal, I now find them brought forward by Williamson, Brodie and Gerhardt. This latter chemist in a paper presented to the French Academy in June, 1852, and published in the *Annales de Chimie et de Physique* for March, 1853, abandons those theories to which I long since objected, and brings forward, with a similarity of thought and expression not to be mistaken, the views upon which I have here insisted. (See as above pp. 336—342.

Williamson in a paper read before the British Association in July, in 1851, has expressed the same ideas with regard to the typical relations of water, and is recognized by the English editor of Gmelin's Handbook (vol. vii, pp. 17 and 201) as the author of the theory. See also Brodie's lecture before the Royal Institution in May, 1853, (Chemical Gazette, Aug., 1st) "On the formation of hydrogen and its homologues."

It is gratifying to find that the views which I have so long maintained, are at last recognized by chemists, and are found productive of beautiful and important results; but it would be only just in these chemists, to have admitted the priority, by three or four years, of my own published views, anticipating the brilliant series of discoveries which have served them as the basis of their generalizations.

Montreal, Dec. 20, 1853.

ART. XIX.—*Notice of a Geological Map of the United States and the British Provinces of North America, with Explanatory Text, Geological Sections and Plates of the Fossils which characterize the formations,* by J. Marcou.*

A GEOLOGICAL map of the United States by a member of the Geological Society of France is likely to command attention both in this country and Europe; and it is therefore important to know how far it is a correct exposition of the present state of American Geological Science. We have therefore examined the map of Mr. Marcou and the accompanying text with much interest, and with no less disappointment. We may briefly run over a few of the earlier pages, and take a cursory glance at the map, for the benefit of the science, mentioning some of the errors, omissions, or objectionable points that have struck us.

In his introduction, after mentioning Maclure, Mr. Marcou speaks of Conrad and Lea, (p. 14) celebrated conchologists of Philadelphia, and leaves out Morton altogether. He then observes that Jackson and Alger published in 1828 a geological description of Nova Scotia, etc., and adds "Such nearly was the condition of geology in America when Murchison published his celebrated book entitled the Silurian System,"—leaving it to be inferred that from 1828 to 1839, when Murchison's work appeared, nothing had been done by geologists in America:—notwithstanding the publication in this period of the Final Report on the geology of New Jersey, the first Final Report on Massachusetts, the An-

* A Geological Map of the United States and the British Provinces of North America, with explanatory text, geological sections and plates of the fossils which characterize the formations. By Jules Marcou, United States Geologist, member of the Geological Society of France, etc., etc. *Boston*, Gould & Lincoln.

nual Reports of Pennsylvania, New York, Ohio, Michigan, Tennessee, and Maine, which gave altogether a very good general view of the Geology of a great part of the United States.

On page 15, the author says, "Troost, Vanuxem and Eaton were also among the first to compare the American formations with those of Europe, and *laid the true foundations on which all the geological maps and memoirs published on this side of the Atlantic for sixteen years, have been constructed.*" Now as one example in point, Troost identified the Silurian of Tennessee with the carboniferous of Europe, and Eaton the Silurian of New York with the New Red Sandstone. Giving every due credit to these named geologists for their labors, which in many respects had important results, nothing is more entirely unfounded than the above quoted assertion; what they did could not by any possibility have served as a foundation for maps and memoirs subsequently published. Mr. Vanuxem did indeed, in the division of the Cretaceous, identify that formation of New Jersey with the same in Europe; and had from the beginning a clearer idea of the age of our geological formations, as compared with Europe, than any other geologist.

The map of Byrem Lawrence, which is next mentioned, in terms of high praise, is essentially copied from a map made by Dr. D. D. Owen, and published in the Transactions of the Geological Society of London.

We proceed to the body of the work.

The *Lingula antiqua*, our author says, "is found in New York, Michigan and Wisconsin." We do not know of it in Michigan;—perhaps in the same locality with *Lingula prima* (Foster and Whitney's Report) in the Lake Superior region, where it occurs in a sandstone which Mr. Marcou further on calls the New Red Sandstone. The last sentence in the same paragraph reads thus: "Its thickness varies with the different localities in which it is found, and depends on the more or less horizontal position of the bed; nevertheless it may be said to vary from 500 to 2000 feet." Prof. Rogers estimates this rock in Pennsylvania with doubt at 1000 feet, and in many parts of the United States it varies from 150 to 300 feet. Dr. Owen estimates the thickness on the Mississippi at much less than 1000 feet, and we do not know any authority for believing it greater than this. Why the thickness should depend on the more or less horizontal position of the bed, is what we do not comprehend.

Under the Trenton Limestone, page 22, we find, "It is in this division that for the first time is presented a complete fauna, representing the first degree of the biologic development of our planet. The first division of the Lower Silurian (i. e. Potsdam) offers only a few species of animals, rarely to be found, and mostly in a bad state of preservation."

The writer appears to be ignorant of what Dr. Owen has discovered in these strata on the upper Mississippi, viz.: *Trilobites, Corals, Crinoids, Orthis, Lingula, etc.* The Lingulæ are in a most perfect state of preservation; and in numbers of individuals unsurpassed in any formation of any period. The author speaks of Barrande's labors in Bohemia, but does not seem to know that Barrande too has described a distinct fauna in these lower beds, or their equivalent in age, and places there very properly, as do all American geologists, the first degree or stage in the "biologic development of our planet."

The author gives, among his characteristic fossils of the Trenton formation, *Orthoceratites communis*, of Wahlenberg, and refers the name to a figure of *Cameroceras trentonense*, evidently copied from Palæontology of New York, vol. i, pl. 56, fig. 4; a fossil very unlike the *O. communis* in every respect. Still further, he cites it as common in New York, Pennsylvania, Canada, the Mingan Islands, on the coast of Labrador, and in Newfoundland, near the straits of Belle Isle. Now the form figured is a rare fossil, known only in a few specimens found in New York.

The author cites *Orthis testudinaria* and *Verneuili*, Dalm., as "species of Brachiopods related to Spirifer, which are found equally in Europe and America." If the author has been as careless of his localities as he has been in his citations of authorities, we can judge very well of his accuracy in this case. The O. Verneuili is one of Eichwald's species, and the figure in Marcou's book is copied directly, reduced in size, from Murchison and de Verneuil's Russia and the Ural Mountains, vol. ii, pl. 12, fig. 1; and is there cited from two localities in Russia, viz., Reval and the island of Dago. This is the first intimation of its having been found in America; and as no locality is given, we may be permitted to discredit it altogether. Orthis testudinaria is an abundant species in Europe and America.

On page 23, it is asserted that most of the blue limestone in the neighborhood of Cincinnati is of the Trenton formation. This was believed ten years since. The author appears not to be aware of what has been published during the last three or four years, or he would not have made the mistake.

On page 24, speaking of the Hudson river group and Utica slate, he says: "Fossils are rare in this division." Perhaps no portion of the palæozoic rocks is more densely crowded with fossils than this group when in an unaltered condition. In central and north New York, in "Upper Canada and Bay des Noquets," the two latter localities cited by our author,—the fossils are extremely abundant. While Mr. Marcou says the only fossils of these rocks are Graptolites and fragments of Trilobites, it is shown in the Palæontology of New York that more than sixty

species of fossils are restricted to these beds, and more than thirty others are common to this formation and the Trenton limestone.

Under the term Upper Silurian our author includes numerous rocks and groups, and among them the Pentamerus limestone of New York. This rock was so named from its containing great numbers of *Pentamerus galeatus*, this being, with its associated shaly limestone, the only position of that fossil. Now our author makes the *rock Silurian*, (p. 25) and describes and figures the *fossil as Devonian* (p. 31). He asserts that it is "common to Upper Silurian and Devonian of Europe, and is in the same geological position in America, but on this side of the Atlantic, it is especially found in the Devonian division." Now this fossil is never found in any rocks of America included by this or any other author under Devonian; nor is it true that it occurs in the Devonian of Europe. Had our author read what was published on the other side of the Atlantic as long ago as 1848, he would have known this.

The author cites Upper Silurian rocks as forming "the upper part of the Falls of the Mississippi at Fort Snelling." The explorations of Dr. Owen and others have shown that the rock is the Trenton limestone; and it is underlaid by a soft, shaly and fucoidal mass representing the Birdseye limestone; and that this rests on a sandstone belonging to the lower formations. It will surprise the ardent collectors of Ohio to learn that they have upper silurian rocks "in the environs of Cincinnati."*

We much incline to doubt whether Fremont, Stansbury, or Wislizenius have brought unequivocal Silurian rocks or fossils from "several points in the Rocky Mountains," and we equally question whether *Pentamerus oblongus* has been found in North Carolina and Minnesota. Lockport, N. Y., Chicago and Minnesota are given as localities of *Favosites gothlandica*, which is not known in either of these places. On page 28, we learn for the first time that "*the Upper Silurian in America often contains beds of rock salt.*" The italicising is ours, the statement is the author's.

Leaving the Upper Silurian, we find under the Devonian, a heterogeneous assemblage of rocks, as one or two citations will show.

On page 29, our author says, "very fossiliferous sandstones form the first devonian beds in Pennsylvania and New York; then comes a great extent of marl and clay, presenting in certain localities quite numerous fossils; and lastly, the whole is crowned by very deep red sandstone, especially at the Catskill mountains, N. Y., at the base of the Alleghany mountains, Pa., and at Gaspé, Lower Canada."

* We know something of the rapid growth of western towns, but we cannot suppose that the environs of Cincinnati extend to forty or fifty miles.

Our author here takes no notice of one of the most extensive limestone formations in the United States, which extends from the Helderberg in New York to the Niagara river at Black Rock, and thence through Canada West, and forms the higher part of Mackinac and the northern part of Michigan proper, or the lower peninsular of Michigan. The same limestone extends from northern Ohio to Tennessee; and though elsewhere noticed, it is here omitted in the description of the successive beds or formations which constitute the author's Devonian System.

On page 30, he says, "Since Mr. Agassiz has recognized carboniferous fishes, and Goniatites in the black slate of Ohio, this group ought to be placed in the lower carboniferous of which it forms the base." Our author has evidently some confused idea that the position of the shales and sandstones of Ohio had been a mooted question, and that it has been settled as above. The truth is that Prof. Agassiz has not recognized carboniferous fishes in the black slate of Ohio; no fishes at all have been found in that slate; neither have any Goniatites been found in the black slate of Ohio; and those found in the black shale of Indiana were not recognized by Prof. Agassiz.

We will cite another sentence following the last noted: "The Island of Mackinac, the Ohio falls near Louisville, and Perry county, Tennessee, have become classic points for the American Devonian, on account of the great number of fossils which are found there, and their identity in species, for the most part, with those found in the Eifel, in the Hartz mountains, and in Devonshire."

Now Mackinac is a locality of Devonian limestone in part, and yielding very few fossils. The falls of the Ohio consist of Silurian and Devonian rocks, each yielding a good number of species. In Perry county nine-tenths of the fossils are Silurian, and their identity with the Eifel species may or may not be true, to some extent. The only fossil cited by the author from Perry county, as far as we observe, is *Hypanthocrinus decorus*, a decidedly Silurian fossil (see page 27, and figure). Our author cites *Spirifer mucronatus*, and applies the name to two figures, both copied from Reports of New York, one of which is the true species, while the other is *Spirifer macronotus*, a widely distinct species, the former having a narrow area and strong plications, the latter a wide area and numerous fine plications. He is equally unfortunate in his localities, citing New York, Ohio, and Tennessee. We suspect that no other person has seen either of these from the two last named localities.

Spirifer heteroclitus, Def. pl. iii, fig. 7, *7a*.—For this species our author has reduced in size two figures of *Spirifer congestus*, from Report 4th, Geol. District of New York, which species differs so widely from *Spirifer heteroclitus*, that we cannot comprehend

how he could have made the mistake. To make the matter worse, he cites the following localities in the United States: "It is very frequent at the Ohio fall, and at Charlestown Road, Indiana; in Ohio, New York, Pennsylvania and Tennessee." Now the species figured is not *Spirifer heteroclitus*, it has not been found at either of the localities named except New York; the species found at the Ohio Fall and Charlestown Road is neither the species figured, nor is it the *Spirifer heteroclitus;* though not only it, but one other species of that vicinity, resembles the Sp. heteroclitus still more strongly than the one figured: and finally, we venture to say, that neither the species figured, nor either of those at the Ohio Fall or Charlestown Road, have been found in the other localities cited.

As an offset to the above, *Chonetes nana*, which is abundant and almost universal in rocks of this age, is cited as found only in the environs of Louisville.

Our author commences his description of our carboniferous rocks by insisting upon the existence of "vast beds of gypsum and rock salt." The former is true of a few localities; as to the latter, one well authenticated locality only, so far as appears, furnishes rock salt.

It is very remarkable that our author should have repeated the same rocks and groups under carboniferous, which have been described under Devonian, viz.: "The bituminous shale, (or black slate) and Waverly sandstone series, and the fine-grained sandstones of Ohio, Illinois, Indiana, the black slate of Tennessee," &c. These names, it is true, are not used, since he has omitted reference to all the western states in his Synonyma of Devonian sedimentary rocks; but as will be seen, he cannot extricate himself from this difficulty. On page 30, he thus describes the Devonian: "To the west it extends through the southern part of the state of New York, forms the whole contour of Lakes Erie and St. Clair," &c. Now the extension of those rocks occupying southern New York, and along the shore of Lake Erie, to form its "whole contour," comes thence into Ohio, not by any identification or parallelism, by lithological or fossil affinities, but by absolute continuity. Yet our author describes first his Devonian as forming the contour of Lake Erie, and afterwards represents the same beds, the bituminous shale and Waverly sandstones of Ohio, as carboniferous,—these very rocks themselves forming the southern contour of Lake Erie.

We have thus run over the work to the 33d page, and here leave it. One point only we will notice. The sandstone of Lake Superior is classed as the *New Red*, notwithstanding all the labors of Logan, Owen, Foster and Whitney, and others, who have agreed in considering it lower Silurian.

We will say nothing of our author's attempts to systematize our mountain chains; if we needed a parody on Elie de Beaumont and his systems of mountains, we have it here.

Mr. Marcou laments the want of accurate topographical maps, and because he has not such guides, he does not lay down on his map any mountain chains, but has "written *near* the places occupied by the different chains of mountains, the names of those chains." For the same reason we suppose, or some other equally cogent, he has given no lines of States, but has written the names of the various states *somewhere near* the places occupied by them respectively. This allows the limits of the various geological formations to be laid down *any where near* the places they occupy, without giving the pupil or the critic the means of determining their accuracy within many miles, a device perhaps convenient for the author, but not so for the student.

The map in its geology is little more than a reproduction of that published by Lyell in 1845, and in many respects it is inferior to that. As we have remarked respecting the text, the sandstone of Lake Superior is represented as the New Red, or of the age of that of the Connecticut, New Jersey, &c. But besides this, he continues a belt of the same formation across from the head of Lake Superior, by the sources of Red river to the head of the Coteau des Prairies. In that direction he again takes up the same formation in the Wind River chain of mountains. In both these instances, there is not the slightest authority for supposing such belts of sandstone formation, and particularly any of the age of the New Red.

Without the slightest reason or authority, and in the face of facts, he runs a belt of lower carboniferous from the coal field of Michigan to the northeastern part of the Illinois coal field, and another from the eastern side of the Illinois coal field to the northwestern side of the Alleghany coal field. The latter is a worse error than the former, for he positively traces it across a broad belt of Silurian rocks which are a prolongation of those to the north of Cincinnati, and which are clearly followed northeastward to the lake shore and the islands west of Sandusky.

In like manner he traces another similar belt of carboniferous rocks to the southward of the Cincinnati axis, connecting the east and west coal field. The idea many years since promulgated that the Waverly sandstone of Ohio did pass around to the south side of this elevation, was long since proved otherwise; and no geologist for the past seven years would have ventured to republish an exploded error.

The union of the coal field of Missouri and Iowa with that of Arkansas is without authority; and so also the extension of lower carboniferous over so great a breadth of territory to the westward.

The Devonian formations, which on the map are colored in a broad belt through New York and thence narrowing westward to Cleveland and Sandusky, are there represented as cut off by the belt of lower carboniferous, before mentioned, which runs westward to the Illinois coal field. Now the fact is, that the formations traced through southern New York and thence to Cleveland, are absolutely and unmistakeably continuous along the western margin of the great Alleghany coal field, through Ohio and Kentucky, and even into Tennessee and Alabama.

Our author has recognized the formation about Richmond, Va. as Liasic, while the same formation in North Carolina is colored as New Red Sandstone. We do not discuss the question of the age of the New Red or Triassic of Connecticut Valley and further south: we only say here that there is no reason whatever for regarding that of North Carolina as differing in age from that of the Richmond basin.

There are other errors with regard to regions less known, as, for example, that of extending the cretaceous area to the east side of the Missouri for several hundred miles above Council Bluffs; and of terminating the same formation on the northwest more than a hundred miles short of its known limits. But these are excusable, compared with many points we have passed in review.

ART. XX.—*On the Chemical Composition of the minerals Algerite and Apatite;* by J. D. WHITNEY.

1. *Algerite.*

IN the Journal of the Boston Natural History Society (vol. vi, p. 118) an account of the analysis by T. S. Hunt of a supposed new mineral, to which he has given the name of *Algerite*, will be found. Another analysis of the same substance by Mr. R. Crossley has been published (see Am. Jour. Science, [2], x, 77).

Having been furnished by F. Alger, Esq. with specimens of this mineral, I have made an examination and analysis of it, the results of which appear to be of interest in their relation to an important branch of mineralogical chemistry, hitherto much neglected, but which has received a new impulse from the laborious and interesting researches of G. Bischof.

The first light thrown upon the real nature of this supposed new mineral species, was by J. D. Dana, who was struck by the evident altered appearance of the specimens examined by him, and published the following remarks (Am. Jour. Sci., [2], xv, 440): "I am satisfied that the form of the crystals is a *square prism.* In external appearance they would not be distinguished

from scapolite, and this naturally suggests some relation to this species." The results which I have obtained in my examination of Algerite seem to sustain the opinion of Dana, and it appears highly probable that this is an altered mineral, and also, as suggested above by Dana, a scapolite of the Wernerite variety.

On the first examination of this substance it seems evident that it is a mineral in the progress of decomposition. In some of the specimens the crystals have been wholly removed from the matrix, or only a trace of a brownish yellow powder left remaining. Their hardness varies from 2·5 or 3 to 3 5 or 4.

A comparison of the results of the analyses of Messrs. Hunt and Crossley will show that the discordances are too great to be explained on the ground of errors of analysis. My own analysis differs still more from theirs, than they do from each other, and though time and material were wanting to enable me to make as accurate a determination of some of the ingredients as I could have wished, yet it seems, at least, sufficient to settle the question of the claim of this substance to rank as a distinct species.

In noticing Hunt's analysis it will be seen at once that the ratio of the oxygen of the silica and bases cannot be expressed by any approximate simple numbers; so, also, in Mr. Crossley's, the ratio of the oxygen of Si, R, R & H is given as 7 : 3 : 1 : 1; while it is really 7·05 : 3·22 : 1·22 : 1.

For convenience of comparison, the results of these two analyses are here given, side by side:

	Hunt.		Crossley.
Silica, - - -	49·82	-	49·96
Alumina, - - -	24·91	-	24·41
Peroxyd of iron, -	1·85	-	1·48
Magnesia, - - -	1·15	-	5·18
Potash and traces of soda,	10·21	potash,	9·97
Carbonate of lime, -	3·94	-	4·21
Water, - - -	7·57	-	5·06
	99·45		100·27

The results of my examinations are as follows:*

Before the blowpipe it blackens a little and soon fuses, intumescing considerably, giving a colorless glass, and glowing with a vivid light.

A small quantity of the mineral, selected with care as being the least altered in character, was ignited in small fragments, and lost 6·20 per cent. of water; another portion, which had the appearance of being more decomposed, lost, under the same treatment 6·68 per cent. The pulverized mineral was found to be

* It is proper to remark that these investigations were made two years since, and that the publication of them has been delayed in the hope of an opportunity to make still farther examinations.

very little acted on by chlorohydric acid, even when digested with it for a long time. The acid however took up a small portion of lime which was intimately disseminated through the mineral in the form of a carbonate. After the ignition it was noticed that portions of the ignited mineral remained nearly unaltered in appearance, while the larger part acquired a brick-red color, and on examination with the microscope was seen to contain silvery white scales, apparently of mica.

As only a small quantity could be used for analysis, the results can be relied on only as approximately correct. They are as follows:

Silica, - - - - - - -	52·09
Alumina, and a little Fe, - - -	18·63
Phosphate of lime, - - - -	8·22
Carbonate of lime, - - - -	4·41
Water, - - - - - -	6·68
Loss, potash and soda? - - -	9·97
	100·00

The difficulty of reconciling this analysis with either of those cited above, on the hypothesis of the algerite being a mineral of a fixed composition, will be apparent. Several specimens were examined and all were found to contain phosphate of lime.

Scapolite is, of all others, a mineral which seems most liable to metamorphosis. Numerous examples of this will be found in Bischof's "Lehrbuch der chemischen und physikalischen Geologie" (ii, 403, 1433, &c.). It is proved by the analysis of a mica in the form of scapolite (from Arendal) that all the lime of this mineral may be removed and a part replaced by potash. It is proved by numerous analyses that a portion of the lime may remain in combination with carbonic acid. It is also demonstrated that the lime may be exchanged for magnesia so as to give rise to a magnesian mica; also that the entire mass may be converted into steatite, or a hydrous silicate of magnesia. My analysis shows in addition to these facts, that in the process of metamorphosis a part of the lime may enter into combination with *phosphoric acid*. It is interesting to notice, in this connection, the analyses by Messrs. Brewer and Garrett of a substance very similar in composition to the Algerite, and also evidently an altered scapolite, which are published in Dana's Mineralogy, third edition, p. 680.

So much is evident, that the Algerite is not a homogeneous mineral and cannot claim to rank as a distinct species; and it is highly probable that it adds one to the already numerous list of the products of the transformation of the scapolite family. Further analyses of specimens from this locality, if such can be obtained, will throw more light on this interesting subject.

2. *Apatite.*

The theoretical composition of apatite according to the latest atomic weights (Ca = 250, Cl = 443·3, P = 400, F = 235·4) is as follows:

	Ca	Cl	$\dot{P}$	$\dot{C}a$		Ca Cl	$\dot{C}a^3\,\dot{P}$
Chlorine Apatite,	3·82	6·77	41·27	48·14;	or	10·59	89·41
	Ca	Fl	$\dot{P}$	$\dot{C}a$		Ca Fl	$\dot{C}a^3\,\dot{P}$
Fluorine Apatite,	3·94	3·72	42·62	49·72;	or	7·66	92·34

There has been a good deal of discussion as to whether the formula proposed by G. Rose was borne out by the analyses. Rammelsberg analyzed the fine crystallized apatite from the Zillerthal,* and endeavored to make a direct determination of the fluorine. He only succeeded in obtaining about one-fourth of the amount required by the formula, and remarks that he leaves it undecided whether this result is due to the imperfection of the analytical processes, or to the fact that the formula needs revision. At the request of G. Rose, R. Weber made several analyses of the Snarum apatite,† the results of which are regarded by Rose as decisive in favor of his formula. C. A. Joy‡ also analyzed a specimen from Faldigl in Tyrol, which gave a pretty near accordance with the amount required by Rose's formula. No one has succeeded in obtaining the required amount of fluorine by direct determination, and the analyses have been made up from the amount of phosphoric acid, lime and chlorine by calculation. It will be noticed that all the analyses give an *excess* of phosphate of lime. There is invariably a deficiency of chlorine or fluorine combined with calcium, and the analyses seem to indicate that the greater the degree of purity of the substance, the nearer the approach to the requirements of the formula. Almost all the analyses of the uncrystallized varieties show a very considerable deficiency in the fluorine and chlorine.

In order to throw some light on this question, I have analyzed a specimen of apatite from Hurdstown, N. J., furnished me by F. Alger, Esq.; the substance examined was broken from a large crystal of a greenish-yellow color, and was translucent on the edges. Two analyses were made, in one of which the separation of the phosphoric acid was effected by mercury, according to Rose's process; in the other the lime was separated by means of sulphuric acid and alcohol. The results were:

	I.	II.
Insoluble,	0·29	0·25
Lime,	53·50	53·37
Phosphoric acid,	43·28	43·17
Chlorine,	——	1·02
Iron,	*trace*	*trace*

* Ramm. 2d Supp., p. 15. † Pogg. 84, 303. ‡ Inaugural Dissertation, p. 44.

These results give on calculation:

	$\dot{Ca}^3\dot{P}$	Ca Cl	Ca Fl
I.	93·77	1·59	3·04
II.	93·54	1·59	3·02

The analyses agree well together, but give too small a quantity of chlorid and fluorid of calcium.

ART. XXI.—*Contributions to Chemical Mineralogy;* by JAMES D. DANA.—Part II.

1. *Relations of Anhydrous Carbonates and Sulphates.*

THE Carbonates that come under the general formula $\dot{R}\dot{C}$, and the Sulphates, $\dot{R}\dot{S}$, present each a case of trimorphism: and a third example of similar character is found in the combinations of Sulphates and Carbonates ($\dot{R}\dot{S}+n\dot{R}\dot{C}$). These cases are as follows; the angles given are R : R in the rhombodedral forms, and I : I (∞ P) in the prismatic:—

Rhombohedral.	*Trimetric.*	*Monoclinic* (basal cleavage).
Calcite, $\dot{Ca}\dot{C}$; 105° 05′	Arragonite, $\dot{Ca}\dot{C}$; 116° 10′	Barytocalcite, $(\dot{Ca}, \dot{Ba})\dot{C}$; 95° 8′
Dreelite, $(\dot{Ca},\dot{Ba})\dot{S}$; 93–94°	Anglesite, $\dot{Pb}\dot{S}$; 103° 38′ Anhydrite, $\dot{Ca}\dot{S}$; 102° 56′ Barytes, $\dot{Ba}\dot{S}$; 101° 42′	Glauberite, $(\dot{Ca}, \dot{Na})\dot{S}$; 83°
Susannite, $\dot{Pb}\dot{S}+3\dot{Pb}\dot{C}$; 94°	Leadhillite, $\dot{Pb}\dot{S}+3\dot{Pb}\dot{C}$; 103° 16′	Lanarkite, $\dot{Pb}\dot{S}+\dot{Pb}\dot{C}$ 85° 48′

There is a remarkable parallelism between the sulphates and carbonates. The difference between the angle of Arragonite and Calcite is about 11 degrees; between Calcite and Barytocalcite 10 degrees. Nearly parallel with this, the angle in Anglesite or Anhydrite is about 10 degrees larger than that in Dreelite, and that of Dreelite is 10 degrees larger than that of Glauberite. The sulphatocarbonates correspond with the sulphates nearly in angle, and confirm this parallelism. Susannite and Dreelite are nearly the same in angle; so also Leadhillite and Anglesite, and Lanarkite and Glauberite.*

It hence follows that the *homologous* prisms in Arragonite and Anglesite are the prisms, above mentioned, of 116° 10′ and

* The angle of Susannite mentioned by Haidinger is that of 2R. Brooke and Miller give Leadhillite another position which makes the angle I : I = 120° 20′. It is probable that this is not the correct position, from the fact that the angle instead of being between that of the carbonate and sulphate of lead, or identical with one or the other, is much larger than that of the carbonate. In another position, taking $1\tilde{1}$ as I, we have I : I = 103° 16′, or near Anglesite. This view is sustained by the relations of Susannite (which is identical with Leadhillite in composition) to Dreelite.

In Lanarkite, according to measurements by R. P. Greg, Esq., recently communicated to the writer, the occurring vertical prism has the front angle 49° 50′; and this being taken as the prism $i\tilde{2}$ (∞ P′2), makes I : I = 85° 48′, as above stated.

103° 38′; and the carbonate and sulphate series differ fundamentally by 10 to 15 degrees. Hausmann therefore cannot be right in making the carbonates and sulphates homœomorphous, by assuming a different prism in Anglesite (one usually taken as a horizontal prism) as the fundamental vertical prism; the alleged homœomorphism was based on a comparison of parts *not homologous*, and does not exist. This conclusion also follows from the fact that the common hexagonal and 6-rayed twins of Arragonite and Cerusite, arising from the nearness of the angle of the prism to 120°, never occur in the sulphates, showing that the angle of the fundamental prism is not near 120°.

2. *Homœomorphism of Beryl, Pyrosmalite, Dioptase, and Eudialyte.*

	O : 1	O : 2*
Beryl, $(\dot{B}e, \dot{A}l)\ddot{S}i^2$ - - - -	150° 3′	130° 57′
Pyrosmalite, $4(\dot{F}e, \dot{M}n)^3\ \ddot{S}i^2 + Fe\ Cl^3\ [+\dot{F}e\ \dot{H}^6$ -	148° 30′	129° 3′
Eudialyte, $\dot{R}^2\ \ddot{S}i^2 + \dot{Z}r\ \ddot{S}i^2$ - - -	148° 38′	129° 21′
Dioptase, $\dot{C}u^3\ \ddot{S}i^2 + 3\dot{H}$ - - - -	148° 38′	129° 21′

O is the basal or terminal plane in each, and 1 is 1P. In Dioptase it is a cleavage plane (1R), and in Eudialyte, although usually designated $\frac{1}{4}$R it is also a direction of cleavage, though imperfect cleavage, and should be taken as 1R.

With the above group, the following may also be compared:

Cinnabar, Hg S, (R=92° 36′)	O : $\frac{1}{2}$=146° 32′	O : 1=127° 06′
Quartz, $\ddot{S}i$, (R=94° 15′)	O : $\frac{1}{2}$=147° 35′	O : 1=128° 13′
Dreelite, $(\dot{C}a, \dot{B}a)\ \ddot{S}$, (R=93°–94°)		
Susannite, $\dot{P}b\ \ddot{S} + 3\dot{P}b\ \ddot{C}$, (R=94°)	O : $\frac{1}{2}$=147° 26′	O : 1=128° 03′

It is possible that the plane $\frac{1}{2}$ in Cinnabar and Quartz may be homologous with that of 1 in Dioptase or Beryl. With regard to Quartz or Dreelite, there is the objection to this view that they do not correspond with Dioptase in cleavage. Taking them as here designated, the vertical axis in each is twice that of Beryl. *Chabazite* also is near quartz in angle.

3. *Homœomorphism of Pyrrhotine (Magnetic Pyrites), Greenockite, Breithauptite, Copper Nickel, Nepheline, Cancrinite.*

Pyrrhotine, $Fe^7\ S^8$; Fe S?	O : 1=135° 16′	O : $\frac{1}{2}$=153° 39′
Greenockite, Ca S,	O : 1=136° 24′	O : $\frac{1}{2}$=154° 32′
Breithauptite, Ni Sb,	O : 1=135° 15′	O : $\frac{1}{2}$=153° 38′
Copper Nickel, Ni As,	O : 1=136° 35′	O : $\frac{1}{2}$=154° 41′
Nepheline, $(\dot{N}a, \dot{K})^3\ \ddot{S}i + 2\ddot{A}l\ \ddot{S}i$	O : 1=136°	O : $\frac{1}{2}$=154° 13½′

Cancrinite and Nepheline are nearly identical in angle. Millerite (Ni S) diverges from the allied species; O : R = 159° 10′, being 4½° beyond O : $\frac{1}{2}$ in either of the above.

* The expressions here used for the planes are essentially those of Naumann, only *i* (or I) is written for ∞, and the P is dropped. In the monoclinic system the clinodiagonal forms are distinguished by a grave accent (`).

These species have O:1 nearly coincident with O:2-2 in beryl (2-2, or 2P2 being a plane on the basal angle of the hexagonal prism). Hence if the series of planes on the angles in Nepheline and others of this group is homologous with that on the edges in Beryl, the two groups would be properly united. But there is no good reason for this supposition. Taking the planes as presented, the vertical axis in the Beryl group is to that in the Nepheline as $\sqrt{5} : 4$.

4. ***Homœomorphism of Willemite, Phenacite, and the species of the Corundum Group.***

Willemite, $\dot{Z}n^3\ddot{S}i$, - - - - - - -	R=115°
Phenacite, $\ddot{B}e\ddot{S}i$ - - - - - - -	R=116° 40′

These angles are the angles of $\frac{1}{2}$R in the Corundum Group, and may be reasonably taken as of $\frac{1}{2}$R in Willemite and Phenacite. $\frac{1}{2} : \frac{1}{2}$ in Specular Iron = 115° 22′. Oxyd of Zinc ($\dot{Z}n$) is shown by G. Rose (Kryst.-Chem., p. 64) to have the form essentially of Corundum; and water ($\dot{H}$) is probably of this group. Corundum has for O : R, 122° 26′, being 4° 40′ less than in Cinnabar, and nearly 6° less than in Quartz.

5. ***Homœomorphism of Apophyllite, Nagyagite, Uranite, Anatase, Matlockite.***

These species have a more or less perfect basal cleavage.

	O : 1
Apophyllite, $(\dot{C}a, \dot{K})\ddot{S}i + 2\dot{H}$ - - -	119° 30′
Nagyagite, $(Pb, Au)(Te, S)^2$ - - -	118° 37′
Uranite, $\dot{C}u\ddot{P} + \dot{U}^2\ddot{P} + 16\dot{H}$ - - - -	118° 35′
Anatase, $\ddot{T}i$ - - - - - -	119° 22′
Matlockite, $PbCl + PbO$ - - -	119° 34′

Hausmannite ($\dot{M}n\ddot{M}n$) is stated to be homœomorphous with Anatase; its angles diverge more widely than the others from the type, O : 1 giving 121° 3′. It is intermediate between this group and the Idocrase series. *Calomel* has O : 1 = 119° 51′. But its cleavage is not basal.

The *Zircon* group, which includes *Zircon*, *Rutile*, *Cassiterite*, *Œrstedite*, have the vertical axis twice that of the group above. O : 1 in Zircon = 137° 50′, and O : 2 = 118° 54′. Hence if the plane 1 in the Apophyllite series may be taken as 2, the groups come together.

The *Scapolite* species, *Scapolite*, *Meionite*, *Mellilite*, *Sarcolite*, may be of the Zircon type. O : 1 in Scapolite is 148° 20′; and in Zircon O : 1*i* (the intermediate octahedron, or, P∞) = 147° 22′. So that if the prism of most perfect cleavage in Scapolite be taken as the fundamental prism, and $\frac{1}{2}$P∞ becomes $\frac{1}{2}$P, the two species correspond in form and angles.

6. *Homœomorphism of Romeine, Idocrase, Cerasine, Chiolite, Braunite.*

The species have no basal cleavage.

Romeine, $(\dot{R}^3, \overline{S}b)\ \overline{\overline{S}}b$	- -	O : 1=124° 05′–124° 35′
Idocrase, $\dot{R}^3\ \overline{S}i + \dot{R}\ \overline{S}i$	- -	O : 1(2)=123° 27′
Cerasine, $Pb\,Cl + \dot{P}b\,\dot{C}$	- -	O : 1=123° 06′
Chiolite, $3Na\,F + 2Al^2\,F^3$	- -	O : 1=123° 17′
Braunite, $\dot{M}n^*$	- - -	O : 1=125° 40′

The plane in Idocrase here taken as 1 is usually made the plane 2.

The *Scheelite* series may be related both to the Apophyllite and Idocrase series. In Scheelite ($\dot{C}a\,\dot{W}$), O : 1*i* = 123° 59′; in Scheeletine ($\dot{P}b\,\dot{W}$), 122° 33′; in Wulfenite ($\dot{P}b\,\dot{M}o$), 122° 26′; in Fergusonite $(\dot{Y}, \dot{C}e)^6\,\dot{T}a$, 124° 20′. But if the planes 1*i* are not homologous with 1 in Apophyllite, and the planes usually given as 1 should be retained so, then the angles O : 1 are between 114° and 116°. In Scheelite, both 1 and 1*i* correspond to cleavages, and the former is most distinct, while the latter is a plane of twin-composition.

7. *Homœomorphism of Sylvanite, Mispickel.*

Sylvanite, $(Ag, Au)Te^2$	I=110° 45′ (B. & M.)	O : $\frac{1}{2}$Y=148° 34′
Mispickel, $Fe\,(S, As)^2$	I=111° 53′	O : $\frac{1}{2}$i=148° 56′

* Volger in his Studien zur Entwickelungsgeschichte der Mineralien, Zurich, 1854, p. 421, in an important chapter on manganese ores, makes Braunite an altered mineral with the original composition $\dot{M}n$, on the ground of a supposed homœomorphism with tin ore ($\dot{S}n$), and rutile ($\dot{T}i$). The angles however are rather remote for such a conclusion. They are much nearer those of idocrase. We have evidence in the dimorphism of idocrase and garnet in connection with the dimorphism of some of the elements and the protoxyds and peroxyds, that a monometric form, a rhombohedral of 85° to 88°, and a dimetric with the form of idocrase, may be the three forms of a trimorph, and hence it seems possible that a peroxyd ($\dot{M}n$) may have an idocrase form. Idocrase, as explained beyond, may be viewed as consisting of peroxyds $\dot{R}^3$, $\dot{R}$, $\overline{S}i$, each containing 3 of oxygen.

Hausmannite is supposed by Volger (p. 414) to be homologous in composition with anatase; and *Polianite* (p. 403) which approaches Göthite in its angles and affords on analysis the composition of Pyrolusite, $\dot{M}n$, is supposed to be an altered $\dot{M}n\,\ddot{H}$, rendered anhydrous by the alteration. *Manganite*, which is generally considered $\dot{M}n\,\ddot{H}$, is regarded by him as probably $\dot{M}n\,\ddot{H}^2$ and homœomorphous with anthosiderite ($\dot{F}e\,\ddot{H}^2$).

The fact is undoubted that most of the manganese ores are liable to alterations by oxydation and gaining or losing water, so that the analyses which are yet few in number, may not give the true composition of the original species.

Volger also makes *Brookite* homœomorphous with *Göthite* (loc. cit., p. 483 and 500). But the resemblance is not close. In Brookite I : I=99° 50′—100° 30′, and O : $\frac{3}{2}$=147° 48′; in Göthite I : I=94° 52′—95°, and O : I=148° 48′. He infers, from the alleged approximation, that Brookite is a hydrated oxyd, and therefore $\dot{T}i$ is *not trimorphous*. Sagenite, or acicular rutile in Quartz, he endeavors to make out either Brookite or pseudomorphs of Rutile after Brookite. Brookite is closely homœomorphous with Columbite, as shown by the writer in this volume, page 86.

8. *Homœomorphism of Andalusite, Topaz, Staurotide.*

I : I in Staurotide is 128° 42′, in Topaz 124° 19′, and in Andalusite (taking $i\bar{2}$ as I), 127° 28′. Compared with Topaz, the plane $1\breve{1}$ (P$\breve{x}$) of Staurotide is $\frac{3}{2}\breve{1}$, and the plane $1\breve{1}$ in Andalusite is $\frac{8}{4}\breve{1}$. The axes in this view are as follows:

Topaz, ($\dot{\mathrm{A}}\mathrm{l}^2\,\ddot{\mathrm{S}}\mathrm{i}$, F replacing some O)	$a : b : c = 0{\cdot}8989 : 1 : 1{\cdot}8931$
Andalusite, ($\dot{\mathrm{A}}\mathrm{l}^2\,\ddot{\mathrm{S}}\mathrm{i}$)	$a : b : c = 0{\cdot}9487 : 1 : 2{\cdot}0263$
Staurotide, ($\dot{\mathrm{A}}\mathrm{l}^2\,\ddot{\mathrm{S}}\mathrm{i}$)	$a : b : c = 0{\cdot}9652 : 1 : 2{\cdot}0825$

The species *Lievrite* has some relations to this group: the prism I, referred to the above type, would be $i\frac{4}{3}$.

9. *Discrasite, Witherite, Aragonite, etc.*

Discrasite, $\mathrm{Ag}^2\,\mathrm{Sb}$	I=119° 59′	O : 1$\breve{1}$=130° 41′
Witherite, $\dot{\mathrm{B}}\mathrm{a}\,\ddot{\mathrm{C}}$	I=118° 30′	
Aragonite, $\dot{\mathrm{C}}\mathrm{a}\,\ddot{\mathrm{C}}$	I=116° 10′	O : 1$\breve{1}$=130° 50′

10. *Augite and Wollastonite.*

In volume xv, [2], page 449 of this Journal, the author pointed out the fact that Wollastonite, by a change of position from that ordinarily taken, and one fully authorized, had nearly the angles of Augite, as follows:

Augite, $(\dot{\mathrm{M}}\mathrm{g}, \dot{\mathrm{C}}\mathrm{a})^3\,\ddot{\mathrm{S}}\mathrm{i}^2$	I : I=87° 5′	O : 2$\breve{1}$=131° 17′	C=73° 59′
Wollastonite, $\dot{\mathrm{C}}\mathrm{a}^3\,\ddot{\mathrm{S}}\mathrm{i}^2$	I : I=87° 28′	O : 2$\breve{1}$=137° 48′	C=69° 48′

The main difference is in the less length and greater obliquity of the vertical axis in Wollastonite, and in the cleavage. The axes are:

Augite, - - - -	$a : b : c = 0{\cdot}5412 : 1 : 0{\cdot}91346$
Wollastonite, - - -	$a : b : c = 0{\cdot}4338 : 1 : 0{\cdot}89789$

It may be of some interest to observe, that the angle I : I in the Augite series is near the rhombohedral angle of the Corundum series, which varies from 84° to 88°.

11. *Pyrolusite and Göthite not closely homœomorphous.*

The angle I : I of Pyrolusite = 93° 40′, and is near the corresponding angle of Göthite and Diaspore. But O : $\frac{1}{2}\breve{1}$ in Pyrolusite is 160°, which gives 143° 57′ for O : 1$\breve{1}$, and this differs 5° from the same angle in Göthite.

12. *Homœomorphism of Monazite, Lazulite.*

Monazite $(\dot{\mathrm{C}}\mathrm{e}, \dot{\mathrm{L}}\mathrm{a}, \dot{\mathrm{T}}\mathrm{h})\,\ddot{\ddot{\mathrm{P}}}$ (I); Wagnerite $\dot{\mathrm{M}}\mathrm{g}^2\,\ddot{\ddot{\mathrm{P}}} + \mathrm{Mg\,F}$ (II); Lazulite $(\dot{\mathrm{R}} + \dot{\mathrm{A}}\mathrm{l})\,\ddot{\ddot{\mathrm{P}}} + \dot{\mathrm{H}}$? (III).

I. I : I=93° 10′; C=76° 14′; O : 1$\breve{1}$=138° 8′ ∴ $a : b : c = 0{\cdot}94715 : 1 : 1{\cdot}0265$
II. I : I=95° 25′; C=63° 25′; O : 1$\breve{1}$=146° 3′ ∴ $a : b : c = 0{\cdot}7401 : 1 : 0{\cdot}9831$
III. I : I=91° 30′; C=88° 15′; O : 1$\breve{1}$=139° 45′ ∴ $a : b : c = 0{\cdot}86904 : 1 : 1{\cdot}0260$

The inclination of the vertical axis (angle C) varies widely; and consequently O on the clinodiagonal prism $1\breve{1}$(P′∞) differs

much. But excepting Wagnerite, the relations between the axes are close. In Wagnerite the plane w (see Brooke and Miller) is taken as the basal plane O.

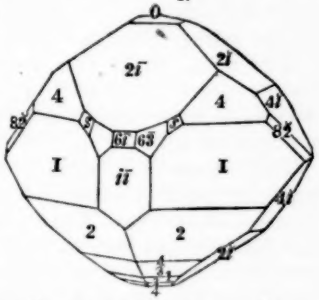
In *Triphyline* I : I = 94°; but the approximation to the others in the value of the *vertical* axis is not very close, even if the prism be oblique. The author has before shown that *Crocoisite* is homœomorphous with monazite.

The Monazite and Apatite series are *mutually dimorphous.*

13. *Datholite and Euclase.*

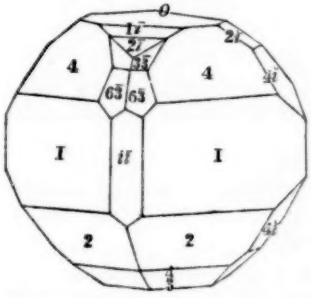
The following figures of crystals of Datholite present some planes hitherto unobserved. Figs. 1 and 2 are from Roaring Brook, Connecticut, and 3 and 4 from Isle Royale, Lake Superior. Fig. 2 presents only a lateral portion of a crystal which in most respects resembles figure 1. A transparent crystal from this locality afforded for I : I, 115° 12′ giving by calculation $i\breve{2} : i\breve{2}$ 76° 28′. The plane O and all the others are highly polished, excepting sometimes $8\breve{2}$, $i\breve{2}$, and usually s; s replaces edge I : $2\bar{i}$; and as its intersections with $6\bar{3}$ and 4 are not parallel, nor is the intersection with $6\bar{3}$ parallel to that of $6\bar{3}$ and $6\bar{i}$, it is probable the plane is $\frac{1}{3}^{6} \breve{-} \frac{\breve{2}}{5}$. The angles of $\frac{1}{3}^{6} \frac{\breve{2}}{5}$ are X = 139° 25′, Y = 57° 8′, Z = 141° 32′. The minute plane t, figure 4, gives

1.

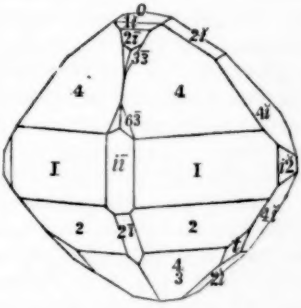


2.

3.



4.



approximately O : t = 140°—142°, $i\bar{i}$: t = 109° 30′, whence t : t = 141°, which are near the angles of plane $2\breve{2}$; but the intersections of t with 2 and $2\bar{i}$ are not parallel, although those with $\frac{4}{3}$ and $4\bar{i}$ are parallel. From the last parallelism $m = 4n \div (2+n)$.

Datholite, as Brooke and Miller show, is trimetric and hemihedral, instead of monoclinic, its hemihedral character giving it a monoclinic aspect. Still it is homœomorphous with Euclase.

In Euclase, I : I = 114° 50′; and $a : b : c = 0{\cdot}4894 : 1 : 1{\cdot}477$.

In Datholite, I : I = 115° 26′ (−12′); $a : b : c = 0{\cdot}5 : 1 : 1{\cdot}5829$.

In each, the axes are very nearly as 1 : 2 : 3.

The homœomorphism of *Sphene* and Euclase is shown by the author in this Journal, vol. xvi, [2], p. 96.

14. *Isodimorphism of Tourmaline and Calcite.*

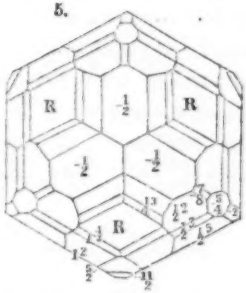
In the last number of this Journal, the author has written for the formula of Tourmaline, $(\dot{R}^3, \ddot{R}, \ddot{B})^4\,\ddot{S}i^3$, (which is equivalent to $(\dot{R}^3, \ddot{R}, \ddot{B})\,\ddot{S}i^4$.)

The species Euclase is known to have the formula $(\ddot{A}l, \ddot{B}e)^4\,\ddot{S}i^3$.

The analogy in these formulas of Tourmaline and Euclase will be observed. And if an analogy in crystallization existed, we should have thereby good evidence that the formula of Tourmaline was right in fact and also in principle.

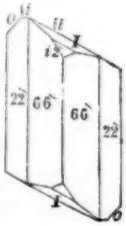
Tourmaline and Calcite are closely homœomorphous, as was sometime since suggested to the writer by Mr. T. S. Hunt. The rhombohedron 2R of Tourmaline has the angle 103°, near 105° 5′ of Calcite. The planes 2R are as highly polished as R, and sometimes more highly so; and there is no reason in cleavage or otherwise for assuming R to be the fundamental form rather than 2R: under this view the planes usually called R (giving the angle 133° 8′) become $\frac{1}{2}$R, analogous to the common nail-head form in Calcite. No objection therefore exists to the homœomorphism of these species. The annexed figure presents a new form of Tourmaline, from Hunterstown, Canada East, for the privilege of studying which the writer is indebted to Mr. Hunt. It is of a rich dark-brown color and transparent, measuring two-thirds of an inch across. It is lettered to correspond with the above views, the plane usually called 2R being made R.

5.

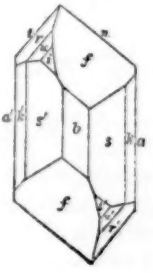


Calcite and Barytocalcite are well known to be mutual dimorphs, and the latter is monoclinic like Euclase. Moreover Euclase and Barytocalcite are approximately homœomorphous. We have copied the annexed figures of Barytocalcite (6) and Euclase (7) from Brooke and Miller, only

6.



7.



changing the lettering of the former. They represent crystals of the species, seen in profile. A resemblance is apparent at a glance; besides, $f : f$ (over edge n) of Euclase $= 106°$; I : I (over ii) Barytocalcite $= 106° 54'$. In Barytocalcite I, I are cleavage planes, and so also the plane O; and making I, I the sides of the fundamental prism and O, the base, the planes are as lettered in the figure. The plane in Euclase corresponding to O of Barytocalcite, would be t. Taking t as O, and f for the comparison as I, the axes of the two species are as follows:

Euclase,	I=106°	$a : b : c = 0{\cdot}83892 : 1 : 1{\cdot}32674$	C=106° 8′
Barytocalcite,	I=106° 54′	$a : b : c = 0{\cdot}81035 : 1 : 1{\cdot}29583$	C=88° 46′

In this view, r, u, i are the clinodiagonal prisms $\frac{1}{3}i$, $\frac{2}{3}i$, $\frac{4}{3}i$; the plane $s = \frac{4}{3}\text{-}\frac{4}{3}$, $k = 1\text{-}\frac{3}{2}$, q, a plane between s and k, mentioned by Brooke and Miller, is the plane 1, or belongs to the fundamental octahedron, having for the angle X, 128° 48′.

Remembering how Anhydrite diverges from the other sulphates $\dot{R}\ddot{S}$ in angles and *cleavage*, and Wollastonite, another lime species from Augite in the same particulars, and also noting the difference in angle between Tourmaline and Calcite, it will be admitted that the homœomorphism is close.

Since then, calcite and tourmaline are homœomorphous, and also barytocalcite and euclase, tourmaline and euclase are mutual dimorphs as well as calcite and barytocalcite; and, moreover, *Tourmaline and Calcite are isodimorphous.*

Hence the formula of Tourmaline, analogous with that of Euclase is the right one; and condensation in writing formulas is apparently the correct method, in place of the hypothetical subdivision adopted by Hermann, and others.

The Laurent School in France is obviously right in making the protoxyds and peroxyds replace one another, the parts equivalent being those having the same number of atoms of oxygen. The principle is sustained by the homœomorphism of Willemite and Phenacite, $\dot{Z}n^2\ddot{S}i$ and $\dot{B}e\ddot{S}i$; or if $\dot{B}e$ be written $\dot{B}e^2$, other cases show the mutual replacement of $\dot{B}e^2$ and $\ddot{A}l$. It is exemplified in Augite and Spodumene, the former $\dot{R}^2\ddot{S}i^2$, the latter $(\dot{R}^2, \ddot{R})\ddot{S}i^2$; and also in many other species.

15. *Observations on the formulas and relations of some species.*

Euclase, Datholite, and Sphene.—The formulas are as follows, in accordance with the above principles.

Euclase, - - - - - -	$(\frac{1}{2}\ddot{A}l + \frac{1}{2}\dot{B}e)\ddot{S}i^{\frac{2}{1}} = (\ddot{R})\ddot{S}i^{\frac{2}{1}}$
Datholite, adopting the above view, and making $3\dot{H}$ replace $1\dot{C}a$ as in Scheerer's theory, has the fomula,	$(\frac{1}{2}\dot{R}^2 + \frac{1}{2}\dot{B})\ddot{S}i^{\frac{2}{1}} = (\dot{R}^2, \dot{B})\ddot{S}i^{\frac{2}{1}}$
Or if $3\dot{H}$ replace $3\dot{C}a$, it becomes, - -	$(\frac{1}{3}\dot{R}^2 + \frac{2}{3}\dot{B})\ddot{S}i^{\frac{2}{1}} = (\dot{R}^2, \dot{B})\ddot{S}i^{\frac{3}{2}}$
Sphene, - - - - - -	$(\dot{C}a + \ddot{T}i)\ddot{S}i^{\frac{2}{1}} = (\ddot{R})\ddot{S}i^{\frac{2}{1}}$

In Sphene there are 3 of oxygen within the brackets as in the other species. The usual formula is $2\dot{C}a\,\ddot{S}i+\dot{C}a\,\ddot{T}i^2$. But the relation in form to Euclase sustains the above mode of writing it. $(\dot{C}a+\ddot{T}i)\,\ddot{S}i^{\frac{3}{2}}$ is equivalent to $(\ddot{R})\,\ddot{S}i^{\frac{3}{2}}$, since $\ddot{R}=RO+RO^2$; so that sphene is essentially a silicate of the common form, or of $\ddot{T}i$ in which part of $\ddot{T}i$ is replaced by $\dot{C}a$. Some chemists write for the sesquioxyd Braunite $\dot{M}n+M_n$, and others adopt the same form for other sesquioxyds, denying the existence of a proper sesquioxyd.

There are but few anhydrous silicates, in which the bases exceed the silica in oxygen. These are *Sillimanite, Kyanite, Andalusite, Topaz, Staurotide*, with *Tourmaline, Euclase* and *Sphene*. Andalusite, Topaz and Kyanite, have the same formula $\ddot{A}l\,\ddot{S}i^{\frac{1}{2}}$; in Sillimanite we have both $\ddot{A}l\,\ddot{S}i^{\frac{3}{4}}$, and $\ddot{A}l\,\ddot{S}i^{\frac{2}{3}}$; and in Staurotide, homœomorphous with topaz and andalusite, $\ddot{A}l\,\ddot{S}i^{\frac{1}{2}}$. Hence the ratio of silica varies in the same species from $\frac{2}{3}$ to $\frac{3}{4}$ (and perhaps to 1) and in the same homœomorphous group, from $\frac{1}{2}$ to $\frac{2}{3}$. The formulas of Euclase, Datholite and Sphene, are therefore essentially of one type. And if this be true, then $\ddot{R}\,\ddot{S}i^{\frac{3}{2}}$ (under which we include $(\ddot{R}^2,\ddot{R}$ or $\ddot{B})\,\ddot{S}i^{\frac{3}{2}}$) is *trimorphous*. (1.) *Triclinic* in Kyanite and Sillimanite; (2.) *monoclinic* in Sphene, etc.; (3.) *trimetric* in Andalusite, Topaz. G. Rose considers Kyanite and Sillimanite distinct in form. But the angles of Sillimanite observed are too doubtful to enable us to decide upon this point.

Beryl and Eudialyte.—These species are shown to be closely homœomorphous on page 211.

The formula of Beryl is $(\frac{1}{2}\ddot{B}e+\frac{1}{2}\ddot{A}l)\,\ddot{S}i^2$; that of Eudialyte, $(\frac{2}{3}\ddot{R}^2+\frac{1}{3}\ddot{Z}r)\,\ddot{S}i^2$. We also add that Pyrosmalite and Dioptase have the ratio 1:2, if the water and also the chlorid in the former be excluded.

Groups of Anhydrous Silicates among minerals.—Making the ratio between the oxygen of all the bases, and that of the silica of fundamental value, the anhydrous silicates among minerals mostly fall into five groups, presenting the ratios 1:3, 1:2, 1:$1\frac{1}{2}$, 1:1, 1:$(\frac{2}{3}-\frac{1}{2}-\frac{3}{4}.)$

I. Ratio 1:3. This includes Edelforsite, $\dot{C}a\,\ddot{S}i$, and Mancinite, $\dot{Z}n\,\ddot{S}i$, both species of somewhat doubtful existence.

II. Ratio 1:2. Includes Wollastonite, Augite, Spodumene, Wichtyne, Beryl, Eudialyte.

III. Ratio 1:$1\frac{1}{2}$. Includes Eulytine, $\ddot{B}i^2\,\ddot{S}i^3$.

IV. Ratio 1:1. Includes—

1. *Trimetric.*	Chrysolite, etc.	$\ddot{R}^3\,\ddot{S}i$	Tephroite,	$\dot{M}n^3\,\ddot{S}i$
2. *Hexagonal.*	Phenacite,	$\ddot{B}e\,\ddot{S}i$	Willemite,	$\dot{Z}n^3\,\ddot{S}i$

3. *Monometric.*	Garnet,	$(\frac{1}{3}\dot{R}^3+\frac{1}{3}\ddot{R})\,\overline{Si}$	Helvin,	$(\frac{3}{4}\dot{R}^3+\frac{1}{4}\overline{Be})\,\overline{Si}$*
	Pyrope,	$(\frac{1}{4}\dot{R}^3+\frac{3}{4}\ddot{R})\,\overline{Si}$	in which	$\dot{R}$=Mn, Fe, Mn S.
4. *Dimetric.*	Zircon,	$\ddot{Z}r\,\overline{Si}$	Meionite,	$(\frac{1}{4}\dot{Ca}^3+\frac{3}{8}\ddot{Al})\,\overline{Si}$
	Idocrase,	$(\frac{1}{4}\dot{R}^3+\frac{1}{2}\ddot{R})\,\overline{Si}$	Scapolite,	$(\frac{1}{4}\dot{R}^3+\frac{3}{4}\ddot{Al})\,\overline{Si}$
	"	$(\frac{3}{5}\dot{R}^3+\frac{2}{5}\ddot{R})\,\overline{Si}$	Mellilite,	$(\frac{2}{3}\dot{R}^3+\frac{1}{3}\ddot{R})\,\overline{Si}$
	Sarcolite,	$(\frac{1}{4}\dot{R}^3+\frac{1}{2}\ddot{Al})\,\overline{Si}$		
5. *Monoclinic.*	Epidote,	$(\frac{1}{3}\dot{R}^3+\frac{2}{3}\ddot{R})\,\overline{Si}$	Zoisite,	$(\frac{1}{4}\dot{R}^3+\frac{1}{4}\ddot{R})\,\overline{Si}$
	"	$(\frac{3}{5}\dot{R}^3+\frac{2}{5}\ddot{R})\,\overline{Si}$	Gadolinite,	$\dot{R}^3\,\overline{Si}$
	Allanite,	$(\frac{1}{3}\dot{R}^3+\frac{1}{2}\ddot{R})\,\overline{Si}$		
6. *Triclinic.*	Danburite,	$(\frac{1}{4}\dot{Ca}^3+\frac{3}{8}\overline{B})\,\overline{Si}$	Axinite,	$(\dot{R}^3, \ddot{R}, \overline{B})\,\overline{Si}$

V. Ratio $1:\frac{2}{3}$ (to $\frac{3}{4}-\frac{1}{2}$). Includes—*Triclinic*, Kyanite, Sillimanite; *Monoclinic*, Euclase and Sphene; *Trimetric*, Andalusite, Topaz, Staurotide, and perhaps Lievrite; *Dimetric*, Gehlenite; *Hexagonal*, Tourmaline.

From the Formulas of Datholite, Tourmaline, Axinite, Danburite, it follows that these are not *borosilicates*, the boracic acid being a *base*. It is a general fact that all mineral species containing boracic acid are either hemihedral or oblique in crystallization.

The *Feldspars* and some other species do not appear at first to come into this system, unless the alumina and silica are considered as replacing one another, and on this ground, any ratio between 1:1 and 1:3 may be made out. The constancy of the oxygen ratio of $\dot{R}$ to $\ddot{R}$ (=1:3) in the feldspars, seems to preclude our taking such a liberty with the $\ddot{Al}$ and $\overline{Si}$. The following are the species, their oxygen ratios, old formulas, and the formulas proposed.

		Oxygen ratio.	Old formula.	Formulas.
1. *Monoclinic.*	Orthoclase,	1:3:12	$\dot{K}\,\overline{Si}+\ddot{Al}\,\overline{Si}^3$	$(\dot{K}+\ddot{Al})\,\overline{Si}^4$
2. *Triclinic.*	Albite,	1:3:12	$\dot{Na}\,\overline{Si}+\ddot{Al}\,\overline{Si}^3$	$(\dot{Na}+\ddot{Al})\,\overline{Si}^4$
	Oligoclase,	1:3: 9	$\dot{R}\,\overline{Si}+\ddot{Al}\,\overline{Si}^2$	$(\dot{R}+\ddot{Al})\,\overline{Si}^3$
	Andesine,	1:3: 8	$\dot{R}^3\,\overline{Si}^2+3\ddot{Al}\,\overline{Si}^2$	$(\dot{R}+\ddot{Al})\,\overline{Si}^{\frac{8}{3}}$
	Labradorite,	1:3: 6	$\dot{R}\,\overline{Si}+\ddot{Al}\,\overline{Si}$	$(\dot{R}+\ddot{Al})\,\overline{Si}^2$
	Anorthite,	1:3: 4	$\dot{R}^3\,\overline{Si}+3\ddot{Al}\,\overline{Si}$	$(\dot{R}+\ddot{Al})\,\overline{Si}^{\frac{4}{3}}$

The following species also belong to the section, as they have the same ratio 1:3 for the protoxyds and peroxyds; Leucite has the composition of andesite; and sodalite, etc., that of anorthite.

* The formula of Helvin, as written by G. Rose, is $(\dot{Mn}, \dot{Fe})^8\,\overline{Si}^2+\overline{Be}\,\overline{Si}+MnS$ MnO. But we conform as closely to the analyses, if we add $\frac{1}{2}MnO+\frac{1}{2}MnS$, when it becomes as above written, or $(\frac{2}{3}(\frac{4}{5}\dot{R}+\frac{1}{5}MnS)^3+\frac{1}{3}\overline{Be})\,\overline{Si}$ = Silica 34·5, glucina 9·4, protoxyd of manganese (part $\dot{Fe}$ in the analysis) 39·8, sulphuret of manganese 16·3.

	Oxygen ratio.	Old formula.	Formulas.
3. *Monometric.*	Leucite, 1:3:8	$\dot{K}^3\,\ddot{S}i^2+3\ddot{A}l\,\ddot{S}i^2$	$(\dot{K}+\ddot{A}l)\,\ddot{S}i^{\frac{8}{3}}$
	Sodalite, 1:3:4	$\dot{N}a^3\,\ddot{S}i+3\ddot{A}l\,\ddot{S}i+Na\,Cl$	$(\dot{N}a+\ddot{A}l)\,\ddot{S}i^{\frac{4}{3}}[+\frac{1}{3}Na\,Cl$
	Hauyne, 1:3:4	$\dot{N}a^3\,\ddot{S}i+3\ddot{A}\,\ddot{S}i+2\dot{C}a\,\ddot{S}$	$(\dot{N}a+\ddot{A}l)\,\ddot{S}i^{\frac{4}{3}}[+\frac{2}{3}\dot{C}a\,\ddot{S}$
	Nosean, 1:3:4	$\dot{N}a^3\,\ddot{S}i+3\ddot{A}l\,\ddot{S}i+\dot{N}a\,\ddot{S}$	$(\dot{N}a+\ddot{A}l)\,\ddot{S}i^{\frac{4}{3}}[+\frac{1}{3}\dot{N}a\,\ddot{S}$
	Lazulite.		
4. *Dimetric.*	Nepheline, 1:3:4	$\dot{R}^2\,\ddot{S}i+2\ddot{A}l\,\ddot{S}i$	$(\dot{N}a+\ddot{A}l)\ddot{S}i^{\frac{3}{2}}$
	Cancrinite, 1:3:4½	$\dot{R}^2\,\ddot{S}i+2\ddot{A}l\,\ddot{S}i+\dot{R}\dot{C}$	$(\dot{N}a+\ddot{A}l)\,\ddot{S}i^{\frac{3}{2}}[+\frac{1}{2}\dot{R}\dot{C}$

The formulas of the feldspars in the last column, show what is equally plain in the oxygen ratios, that the species differ in the amount of silica, and this is the great essential difference. It is least in anorthite; and from this species it increases to $4\ddot{S}i$ in albite or orthoclase. This increase takes place without any change of crystallization, there being only very small variations in the angles. In anorthite, the oxygen ratio for the bases and silica is 1 : 1; and as anorthite is common in good crystallizations, and is every way a well characterized species, it shows us that 1 of oxygen of the silica to 1 for the bases is all that the *feldspar type* requires. Moreover, the relation of the species to Scapolite, which has the ratio 1 : 1, also favors this view. Hence 1 : 1 may be considered the *type-ratio*, upon which, variations take place according to definite proportions. When silica abounds in the rock material in process of crystallization, and the other ingredients are at hand, the species holding the largest proportions of silica would be formed.

The isomorphism of Sodalite, Hauyne, and Nosean, and dimorphism with Anorthite, parallel with the dimorphism of Leucite and Andesine, show that the ratio 1 : 3 : 4, is their type ratio. The very unlike substances $Na\,Cl$, $\dot{C}a, \ddot{S}$, $\dot{N}a\,\ddot{S}$, are added without modifying the form, and although chemically included, are unessential to the type. The same is true of $\dot{R}\dot{C}$ in Cancrinite, which has the crystallization of Nepheline.

The facts above exhibited appear to show that a type admits of some variation in the amount of silica without changing the character of the species. In Meionite, having the ratio of 1 : 2 : 3, the scapolite type is exhibited; and Bischof and Rose take this as the only ratio of the species. But the ratio 1 : 2 : 4 appears to be required by most analyses of Scapolite, in which there is an addition to the silica. In the same manner $\dot{R}^3\,\ddot{S}i2$, with an addition of $\frac{1}{3}\ddot{S}i$, becomes Hornblende.*

Among the feldspars, Andesine and Leucite have essentially the oxygen ratio of Augite, $1+3:8=1:2$, and the formula might

* The amount of silica present may be one cause leading to the formation of Hornblende in place of Augite. But in pseudomorphic changes, the same proportions may result, by a removal of part of the bases, or an addition of magnesia as Blum and Bischof have suggested.

be written $(\frac{1}{4}\dot{R}^2+\frac{1}{4}\ddot{R})\ddot{S}i^2$. Moreover, oligoclase has similarly the oxygen ratio of Hornblende $= (\frac{1}{4}\dot{R}^2+\frac{1}{4}\ddot{R})\ddot{S}i^{\frac{9}{4}}$. Hence we may look upon Leucite, and Andesine, with Pyroxene, as in a certain sense trimorphous. Still, their relation to the feldspar series is such that they are naturally classed with the other feldspars.

The zeolites, if the water be excluded, have the oxygen ratios of the feldspar-section, as shown in the following table; the oxygen of the water in the zeolites is annexed to the name of the species :—

Oxygen ratio. $\dot{R}\ \ddot{R}\ \ddot{S}i$	*Feldspars.*	*Zeolites.*
1 : 3 : 4	Sodalite, Anorthite,	Ittnerite (2), Thomsonite ($2\frac{1}{2}$).
1 : 3 : $4\frac{1}{2}$	Nepheline,	Zeagonite ($4\frac{1}{2}$).
1 : 3 : 6	Labradorite,	Levyne (4), Natrolite (2), Scolecite (3).
1 : 3 : 8	Leucite, Andesine,	Analcime (2), Chabazite (6 or 5). Philippsite (5), Laumonite (4).
1 : 3 : 9	Oligoclase,	Harmotome (5), Chabazite (6).
1 : 3 : 12	Orthoclase, Albite,	Heulandite (5), Brewsterite (5). Stilbite (6 or 5), Epistilbite (5).

Some of the species are correspondingly isomorphous with feldspar species, as Analcime with Leucite, Ittnerite with Sodalite; and the ratio 1 : 3 : 12 produces oblique forms in both series. But we do not intend to draw a general parallelism, as the water whatever its relations, must in some cases modify the ratios. But as regards the origin of the species, the table is an interesting one. Bischof remarks on the identity in the ratio between the oxygen of the bases and silica in chabazite and that of Hornblende, and thereby explains the occurrence of pseudomorphs of chabazite after hornblende.

Pyrrhotine (Fe^7S^8) *and Greenockite* (Cd S).—As Pyrrhotine and Greenockite are homœomorphous, they are naturally arranged in the same group, although the former has a little too much sulphur. The formula $5Fe\,S+Fe^2\,S^3$, may perhaps be written $Fe\,S\,[+\frac{1}{3}Fe^2\,S^3]$, the latter term being unessential to the type.

Art. XXII.—*On Microscopes with large Angles of Aperture;* by Dr. E. D. North.

We have no fuller or more careful statement of the mode in which an enlarged aperture increases the efficiency of a Microscope than that of Mr. Pritchard in his "Microscopic Illustrations," which is copied by Mr. Quekett. After explaining that since the whole diameter of the front lens receives a pencil of rays from each minutest point of the object, and that, consequently, when these pencils from each point are large, more light is received from the points separately as well as from the entire object, he adds :—

"But it may perhaps be supposed from this reasoning, that if we throw a greater quantity of light upon an object, so that more may be collected by the object-glass, we shall be better able to define a structure; which would probably be the case if the additional light could be thrown only upon those minute parts of the object which we wish to examine, and not upon the whole object. But as we cannot do this, as the increase of illumination cannot be made to increase the *relative* proportions of light which proceed from those minute parts, the intended advantage will not be derived."

This paragraph involves implications directly opposite to some of the most important facts in regard to using Microscopes successfully. The second sentence says in effect, that when, with an object-glass of small aperture, and in a faint light, we discover a certain degree of minuteness of structure, we shall, under a strong illumination, discover no more, which is directly contrary to the fact, unless the objective is miserably deficient in correction. Indeed, a most important quality of first rate objectives, is their ability to bear a strong illumination.

It is also taken for granted that an increase of the *relative* proportions of light upon minute striæ and other markings, would enable us to see them better. On the contrary, the true requisite is that the objective shall be so perfectly corrected as to *preserve* the relative light, shade, and variations of color on adjoining minute portions, thus exhibiting the object precisely as it would appear were its smallest parts *large enough* to be visible to the naked eye. If some parts could be illuminated more than others, a false instead of a true appearance would be the result. By destroying the natural shading, we should get the appearance of a different object.

The *limit* of beneficial intensity of light depends rather on physiological than on optical conditions, being different with different individuals; one person's eye being pained and dazzled, when another's is aided. The direct light of the sun enables the aged to read without spectacles. It will be well, however, to notice that, although intrinsic brightness may be the same and very intense, yet if all the light entering the pupil comes from a minute surface, the eye is less affected on the whole. Place a card with a pin-hole at each end of a tube, and hold the latter near the eye, and we can gaze steadily at the small portion of the sun thus visible. But in general, the dazzling and blinding effect of intense light is owing to contrast, as when one comes from a dark room into sunshine. The contrast may be of surrounding objects, as in viewing in a darkened room the light of a galvanic battery.* In reference to extreme intensity of illumination, the

* By means of this contrast of light on a black ground, fine displays may sometimes be made of lines on test objects: thus, by using sunlight with Mr. Wenham's admirable condenser, the transverse lines of the Grammatophora subtilissima, (Greenport, in balsam,) are shown at regular intervals and sharply defined, the objective being Smith & Beck's $\frac{A}{10}$, of largest angle.

following observation is most important. Artists, such as painters, engravers, sculptors, never employ a strong light on their work. The most important discriminations for them, are delicate gradations of color, of shadows, or of the mingling of the two. Their eyes, according to our observation, are by natural constitution very easily pained and dazzled. The finest artistic effects are possible only in a subdued light. An able writer on painting, remarks: "It is the property of (strong) light to convert objects into its own whiteness, and to take away color." Dimness of light and indefiniteness of outline, assist an active imagination. Faint illumination in the microscope may gratify an artist's eye by making the representation more pictorial, and especially by assisting the imagination in regard to depth. Such pictorial effects are suited to the popular eye, and it is allowable for the most accurate and reliable observer to gratify himself and friends with them as exhibitions of a peculiar kind. The object of the common Stereoscope, is to produce a pictorial, rather than a geometric impression on the mind: yet the brief reports as yet published respecting stereoscopic vision applied to the microscope, have not often discriminated these two kinds of effect.

The most minute objects now examined under the microscope, are colorless and transparent, and consequently do not need a diminished illumination for bringing out delicate variations of color, and, as is the case with the naked eye, it may be said in general that the more the light, the more distinctly will the minutest portions cast a shadow or reveal themselves by their refractive and dispersive effect, up to that degree of general brightness of the image which a given eye can bear.

But what constitutes the *extremest minuteness* in regard to visibility? Simple and obvious as the answer is to this question, yet writers on the microscope speak of an increased angle as if it could in all cases compensate for a higher magnifying power.

As is the case with the telescope, or with the naked eye, an area is visible when it subtends an angle at the eye of at least "more than half a minute of a degree." Or, it may "be assumed that one minute of angle is a good general measure for the *visibility* of areas"—"therefore, that areas are visible at a distance of about 3,000 or 4,000 times as great as their diameter." "But though such a spot can *be seen*, it cannot be *defined* as square, circular, &c." "To be thus clearly defined to the naked eye, black spots on a white ground, must have a diameter of about $\frac{1}{1200}$ of radius." But black stripes can be separated when areas cannot be defined, and the whole is greatly dependent on illumination. As no two persons' eyes have precisely the same power of minute vision, the limitation in question must be to some extent indefinite; it deserves, however, and will doubtless receive further investigation.

Yet it is important to keep in mind that there *is* a limit which no illumination or enlargement of aperture will overcome without increase of magnifying power. It may lead to serious error to be accustomed to strain the eye with a low eye-piece or objective, when a more extended amplification of image ought to be employed for more decidedly separating lines or points. M. Robin argues for employing high powers in anatomical investigations, with an earnestness which proves a then prevalent error. Probably such mistakes have contributed to establish an impression of there being often a danger of using too much light. When endeavoring to look into minute structure with a low or medium power, when a high one is what is needed, one will unconsciously strain and prolong his attention, until, if the light be strong, he brings on confusion, dazzling and pain, which a weaker light may alleviate, and at the same time be sufficient for what the given amplification can reveal. As long as an increase of light assists the mind it can be borne by the eye, as is indeed proved by the present fashion of employing sun-light. Not only high powers, but well corrected medium ones, and even rather low ones, may thus be used, and that too with no diminution of light by obliquity. Fatigue and dazzling of the eye result also from aberration, as we shall presently show.

It may be well to mention a curious effect which is quite liable to result from attempting to accomplish too much with a given objective. When an object-glass is thus *overstrained*, a test may exhibit a set of lines, or even two sets, crossing each other, and forming dots, which are not the true lines, *because two or three of them are united into one.* The case is not similar to the *doubling* of lines, which is so often noticed. Although not well defined, those now in question are seen *in focus*, and although thickened and badly defined, are yet plainly visible and easy to count in micrometrically measuring their distances. Among other experiments in proof, the following is selected: The ribs of Pinnularia major were viewed with a low objective and intense lamp light, (sunlight is still better,) at an obliquity, very near the degree which produces a dark back-ground. The ribs were strongly visible, though not entirely across the semi-breadth of the valve. Being easily counted, the micrometer gave their distances $\frac{1}{8000}$ and $\frac{1}{6000}$ of an inch in different circumstances, with sufficient accuracy for the experiment. But when with the same light and illumination, a $\frac{1}{4}$th objective was employed, the ribs were visible in their whole length, and with a perfect definition. Their distance was, in the specimens examined, beyond all room for doubt, found to be very accurately equal to only $\frac{1}{14000}$ inch. Two acute microscopists and practiced observers, one of them an able microscope maker, witnessed, and themselves repeated this demonstration, and confirmed its reliability. The experiment

will be found instructive and also easy by microscopists in general. A friend also mentions that he had noticed the same optical effect; and with sun-light had shown to two persons, one being a distinguished microscopist, that even when a power so low as one inch (a remarkably good one, however, by Mr. Grunow) was employed on the Navicula Angulata, lines of the *true* obliquity in reference to the sides were brought out, although so far apart and few in number, as manifestly to consist of but one in a space which really contains as many as three or four. The finest scales of the Lepisma Saccharina, with an objective of 1½ inch, or probably the coarser scales with a power even considerably lower, are convenient for this purpose. Undoubtedly, tests of very close markings are often supposed to be resolved, when in fact only half the number of lines is seen, and these thickened, flattened, and badly defined. We do not see how the performance of an objective can be stated scientifically, except on Nobert's lines or when it is confirmed by the micrometer.

It is obvious that as the *image* of a faint star in the telescope, so is an indivisible point or line in the image formed by the objective of a microscope. In both instruments the necessary condition of visibility is that light enough come from a point in the image to stimulate the optic nerve sufficiently. Hence when the desideratum is not to *separate two points*, but to perceive the existence of a solitary one, to magnify in a higher degree without at the same time admitting more light, may cause the point to vanish from sight. Low eye-pieces are appropriate for *discovering* faint markings, higher ones for separating those whose obscurity comes from being extremely near to each other.*

The demand for light in using high magnifying powers is enormous. A minute anatomist when dissecting under a low magnifier, or with the unaided eye, illuminates a tissue with as much light as possible, often employing two condensers of artificial light, yet as the brightness of an image is diminished in inverse proportion to the square of the linear magnifying power, an ultimate fibrilla of voluntary muscle, when magnified 1000 diameters (and as much or more amplification is needed), would have only $\frac{1}{1,000,000}$th part the light on its image, were it not for the large aperture of the objective.

With a microscope just as with a single eye, we judge of depth and form, by means of geometrical foreshortening and infinitely delicate gradations of light, shade, and sometimes color; assisting our conclusions by change of focus and directing attention to different parts and presentations. Nothing shows more strikingly

* The President of the London Microscopical Society remarks that although Mr. Wenham thought the apertures which he had gained were of no utility beyond 150°, yet to himself they seemed to have greater power of discovering or indicating the existence of lines, though they were insufficient for defining them. In this remark the same principle is recognized.

the perfection of the human eye than this power of looking at points in the plane of the exact focal distance, and yet at the same time receiving impressions *appropriately indistinct* from points within or beyond the focus. It is the same, though in less pefection, with a well corrected object glass of large angle; in proportion to the length of its focus, do points beyond the focal distance form *suitable* images. But upon this requisite more will be said presently. The power of exhibiting minute variations of light and shade thus being essential in reference to solid form and also being that chiefly by which lines are separated on a plane surface, becomes obviously the most valuable quality of an objective.

No object glass can be wholly freed from the two kinds of aberration. Of these the spheroidal is the most difficult to correct, particularly when the residuum of error is to be magnified by an eye-piece.

Mr. Pritchard should therefore have explained that when an objective has a small aperture, and is at same time not well corrected, the more light is sent through it by increasing the illumination, the greater is the amount of uncorrected aberration, which has its confusing effect subsequently magnified with the rest of the image. But if additional brightness of the image and greater amount of light entering the eye is gained by enlarging the angular aperture, the lens must be corrected for this aperture or no definition is gained. The benefit from large aperture, then is as before, simply that of an increase of light. If the spherical and chromatic aberrations could be *perfectly* corrected, a stronger illumination would assist an objective of small aperture, precisely as it does the naked eye, up to a surprising degree of intensity, while injurious extremes would be farther removed by success in discrimination, and the pleasure of the exhibition.

But images are formed more by the marginal than the central rays, as these are the most numerous; yet as spherical aberration increases in proportion as rays are further from the center, the outer ones are most difficult of correction; and the residuum of error increases from the center towards the margin. Objectives with large apertures, therefore need to be more skillfully corrected than those with small ones, or they cannot be used at all; a fact which should be called to mind by any one disposed to sneer at Mr. Spencer in regard to his enormous apertures. It is this better correction needed for large angles which explains the peculiarity of the most perfect object glasses being as much superior for a stronger as for a weaker illumination. Dr. Goring reported that only the coarsest tests could be resolved by sun-light; at present some rely upon it solely for those of extreme difficulty.*

* A striking illustration of the effect of large apertures, and of that degree of correction which is indispensable, was afforded by the surprise which some micro-

The following experiment is interesting:

Let any one who has an objective with a large angle, try it in a room nearly dark, no light being had except from a small lamp or a candle in an adjoining one. Let the rays from the distant candle shine on the stage of the microscope, which yet receives so little light that with the naked eye the smaller letters cannot be read upon an engraved bank bill which is laid on the stage, and receives no condensation of light from a lens or a concave mirror. Then looking through the microscope at the bill as an opake object, he will not only be able to read the characters, but distinguish the finest lines of the engraving and make out the texture of the paper. Employing transmitted light and the concave mirror, he may determine the fibres, whether cotton or linen, of which the paper is composed, and even do this, with some objectives, when the amplification is the excessive one of 2000 diameters. So, also, we may examine as an opake object, a scale of a fish, the wing of a moth, a feather, a leaf or a petal, by diffused daylight, without Lieberkuhn or other condensing apparatus, and, under a low magnifying power, we shall perceive, not only more clearly than with a hand lens, but also more plainly than with the naked eye, those coarser details which need either no amplification or but a slight one. The instrument has the same effect as if it not only magnified, but illuminated the object, and with a light surprisingly clear, uniform, and pleasant. It is not useless to mention such facts, for there are probably many who do not know, and little suspect the perfection of the best instruments as now made, and their superiority not only in pleasantness, but trustworthiness over the single microscope.

Large aperture being so important, it has become customary simply to mention its extent in commending an objective. Dr. Goring seldom mentioned the magnifying power of an object glass needed for a particular test; but in regard to the tests now most used, which require to be magnified so much more, no accurate account can be given except such as specifies the degrees of the two qualities, aperture and magnifying power, which are needed for their resolution. Indeed, expansion and definition sufficient for counting with a micrometer, is the only standard which can enable one investigator to compare his observations with those of another.

Of late, the superior correction which opticians can accomplish on medium powers, makes them more efficient than higher ones even on tests for which the greater expansion of image of the latter is an important advantage. A smaller angle now will often accomplish more than one larger by a half. The anticipation of

scopists felt, on reading the report of the Jury of the Great Exhibition, pronouncing the objectives of M. Nachet to be *uncorrected* for *spherical* aberration. But this artist's angles fall much short of Mr. Spencer's. Persons accustomed to the effect of refined spherical correction were less surprised.

Mr. Pritchard* that large apertures by permitting a longer conjugate focus, may ultimately enable all organized structure to be investigated with ⅛ inch glasses, has been fulfilled sooner than he probably could have anticipated. Objectives of this grade now resolve every known test.

Of the two unavoidable remainders of error, the spherical becomes the most important for farther reduction; we thus gain not only in what is called definition, that is fineness and delicacy of lines, but in light and shade, in depth, and even in light. Take a ⅛ inch object-glass of very fine definition, but an aperture no larger than reported by Mr. Quekett (between 60° and 70°) and one of the Naviculæ whose lines it will resolve, though not too readily—one with diagonal lines being best for this purpose. Adjust the screw collar for an *uncovered* object, and let the cover on the slider be a thick one, or interpose another piece of thin glass; better also for the object to be mounted in balsam. Turn down the wick of a lamp and remove the light till there is barely light enough to see the lines yet only on a part of the valve; fixing the eye on a portion of the surface where the lines seem to be hidden by a dark shade, adjust the front lens for the thickness of cover, and this shade will disappear; the lines will come out and the whole object *appear* better illuminated. Compare this effect of correcting the spherical aberration by the screw collar, with that of suffering it to remain uncorrected, and bringing out the additional lines by bringing the lamp nearer. The two effects may be made the same.

An objective may bring out a single set of lines on a Diatomaceous test, especially if sun-light be employed, in a strong and bold manner (though thickened and perhaps highly prismatic) when its deficiency of spherical correction shows them through a mist and does not show a perspective definition of general form. Among the Diatomaceæ, the genus Nitschia was established by Hassall who yet makes no mention of its most distinctive characteristic, the prominent keel, which strikingly distinguishes it from Synedra *(Exilaria)*, as is shown by the Rev. Wm. Smith: yet the founder of the genus, though he expressly notices the connection of the two genera, failed to point out this mark of difference which at once attracts the attention if a first-rate objective be used.

If angular aperture be *unnecessarily* large, we have the disadvantage of a useless or injurious limitation of focus—even supposing the *working distance* to be not too inconvenient. Taking the semi-diameter of front lens as radius, the working distance is the tangent of the inclination of the extreme rays: when this inclination, as in large apertures, is small, the tangent varies more nearly as the angle, and any error of focus causes the outer rays

* Micrographia, Essay on Solar Microscopes, 1839.

to have more aberration. View of depth is therefore necessarily more limited. Still, for extremely slight elevations and depressions, and for very thin objects, some restriction will afford a more exquisite discrimination, provided the spherical correction is carried to a degree of perfection in due proportion to the angle. Indeed, whatever tends to bring the performance of an object-glass nearer to mathematical exactness, must limit its focus. Stop off aperture and we see farther in depth, because we see more indistinctly in regard to minute details. Again, we may gain the same advantage by so setting the screw collar as to increase the spherical aberration. Since the longer the focus of a glass, the more power will it have over depth, the ordinary resource is, to employ an objective of lower magnifying power. By whatever means the image is enlarged, the points of the object which form it must lie more nearly in the same plane; higher eye-pieces or longer tubes have the same effect as higher objectives. The question of "pleasantness" in regard to degrees of aperture, will therefore depend upon the investigations in which individual observers are employed, and their tastes and acquired habits. The most interesting suggestion of possible evils from very large angles, is that lately put forth by Mr. Wenham: that the projection of a solid upon a front lens near its margin being almost that of a side view, when extremely oblique, a number of different projections are thus made to overlap each other in the image. It is very instructive to repeat this gentleman's experiment. Looking at an insect's egg shell with a circular opening, the plane of the circle lying oblique to the horizon, a right hand and left hand view of the circle gives different elliptical projections. These different ellipses may be produced by interposing a slip of card and cutting off alternately the right and left sides of the front lens of the objective. We thus gain two different forms of the object, both of which are received together in ordinary microscopes. The same change of form may be effected by covering one-half of the eye lens of the instrument. Mr. Wenham's figures were taken by a $\frac{3}{8}$rd object-glass. The effect becomes much more striking when we experiment with a higher power and an angular aperture three times as wide. But whatever be the power or angle, if the definition be good the upper and lower sides of the circle *are not in precise focus at the same time.* It is not necessary for producing these changes of form to cut off a part of the pencil at all; as we carry the focus from the upper to the lower edge, the ellipticity of the figure is plainly seen to change, as evidently by the laws of geometry it must do, from the change of angular direction of its different points to the lens. Instead of the right and left, the upper and lower sides of the lens may be cut off, a requisition for which stereoscopy does not provide, although it may be thought of importance in regard to large apertures.

Again, if we bring into focus the under side, say, of the circle, we may notice a slight mistiness about its general outline, which may be removed by cutting off half the objective front lens, or of the eye lens. But on more careful examination, we shall perceive that we are bringing no one point into perfectly accurate focus, and at the same time concentrating our attention upon it. If these two things be attended to, all mistiness, thickening, and uncertainty, will disappear from such objectives as this gentleman employed. Such facts are no real obstacles to microscopic accuracy. They occur equally in unaided vision, whether of small or of large objects. If possible, we hold a solid body—a crystal for instance—in the hand, and turn it about, yet each change of position projects a different geometrical figure. The laws of vision are the same with a microscope as without, and no perfection of instruments can supersede the necessity of comparing different views and of arriving at a knowledge of the third dimension in space, through operations of the mind.

In some cases a restricted focal distance is both convenient and advantageous: one is when we look through a set of markings. The Stauroneis pulchella of Rev. Wm. Smith, is described by him: "striæ very distinct, 30 in ·001″, punctate; puncta hexagonal." In his introduction, Mr. Smith remarks: "The experiments and authority of Professor Bailey place the existence of an internal membrane (in the Diatomaceæ) beyond all doubt."—"In Stauroneis pulchella the membrane in question possesses an unusual degree of firmness, the siliceous valves, after a slight maceration in acid, may be seen to fall away from the internal membrane and to leave the latter unaltered in form."

Specimens in balsam from London, prepared by the author of these remarks, exhibit the following appearances: under a $\frac{1}{4}$ of between 60° and 70°, with a working distance sufficient for a Lieberkuhn, and having (to quote the term applied by the Jury of the Great Exhibition) the "exquisite" correction of Smith and Beck, they show by an achromatic condenser, the hexagonal puncta in three sets of lines, yet obscured in definition, and confused by the mingling of what seem like shadows.

Intense illumination of a suitable obliquity and direction, exhibits a set of fine striæ in a plane *above* these puncta, and running in directions which coincide with neither of the lines of puncta. So far, some would make the objection of "optical appearances." But when the focus is limited by the joint influence of the still more perfect correction, and the increased angles of the $\frac{4}{10}$ of 100°, the $\frac{1}{5}$ of still larger angle, and the $\frac{1}{8}$ of 120° to 128°, these two distinct sets of markings may be seen with either perpendicular or oblique light, simply by carrying the focal distance from the one to the other, and without changing the illumination. The upper striæ are at the distance quoted; the hexa-

gons below are twice as distant; each set in turn may be seen in in its own plane, and without confusion from the other. We do not refer to these hexagons as an instance of the interior membrane referred to in the passage just now extracted, which seems to indicate a different one. The appearances are the same on every specimen, and fragment, whether lying flat or edgewise. The striæ are similar, only more difficult to distinguish with accuracy, to the *fine* diagonal markings on the surfaces of Triceratium, Actinocyclus, Coscinodiscus, and other genera which have large hexagonal cells.

An able optician from Berlin says that the importance of spherical correction is but imperfectly understood in Germany: we thus find accounted for the mistakes of Ehrenberg, which have caused so much surprise, and Dr. Hannover's omitting all mention of a screw collar, in a work of such merit as to be selected for translation into English.

ART. XXIII.—*Further Notes on Cereus giganteus of Southeastern California, with a short account of another allied species in Sonora;* by Dr. GEORGE ENGELMANN, St. Louis, Missouri.

SPECIMENS of flowers and fruit, together with interesting notes and drawings communicated by Mr. George Thurber, and specimens of ribs of the plant with spines presented by Dr. Parry, enable me to perfect the history of this giant Cactus.* Mr. Thurber travelled through the Gila country and Sonora, as one of Mr. Commissioner Bartlett's party, in the summer of 1851, and is believed to be the only scientific gentleman who has seen the plant in question in flower. These materials enable me to furnish the following detailed character.

CEREUS GIGANTEUS, *Engelm.:* erectus, elatus, simplex, s. ramis paucis erectis caule cylindrico versus apicem sensim attenuato brevioribus candelabriformis; vertice applanato tomentoso; costis ad basin caulis sub-12 versus apicem 18–20 rectis obtusis (vetustioribus ad caulis basin obtusissimis) subrepandis; sinubus ad basin caulis latissimis versus apicem profundis angustioribus angustissimisque; areolis prominentibus ovato-orbiculatis junioribus albido-tomentosis; aculeis rectis basi valde bulbosis tenuiter sulcatis angulatisque albidis demum cinereis, radialibus 12–16 imo summisque brevioribus, lateralibus (præcipue inferioribus) longioribus robustioribus subinde cum aculeis adventitiis paucis setaceis summo areolæ margini adjectis; aculeis centralibus 6 robustis albidis basi nigris apice rubellis demum totis cinereis, 4 inferiori-

* See this Journal, New Series, vol. xiv, page 335, Nov., 1852.

bus decussatis quorum infimus longissimus robustissimus deflexus, 2 superioribus lateralibus brevioribus; floribus versus apicem caulis ramorumque sparsis, tubo ampliato breviusculo petalisque patulis; ovario ovato sepalis 25–30 squamiformibus triangulatis acutis in axilla fulvo-villosis stipato; sepalis tubi sub-30 orbiculato-subtriangularibus mucronatis, inferoribus in axilla lanigeris, superioribus nudis, sepalis intimis 10–15 spathulatis obtusis carnosis (pallide viridibus albescentibus); petalis sub-25 obovato-spathulatis obtusis integris crispatis coriaceo-carnosis crassis (flavescenti-albidis); staminibus numerosissimis, filamentis superiori tubi parti adnatis (inferiore nudo); stylo stamina paulo superante; stigmate multifido; bacca obovata squamis sepaloideis triangularibus carnosis minutis ad axillam fulvo-lanatis stipata, pericarpio duriusculo carnoso, demum valvis 3–4 patentibus reflexisve dehiscente; seminibus numerosissimis in pulpa saccharina nidulantibus oblique obovatis lævibus lucidis exalbuminosis; embryone cotyledonibus foliaceis incumbentibus hamato.

This species ranges from north of the Gila river southwardly into Sonora, to within 20 miles of Guaymas on the Californian Gulf. It doubtless also occurs on the Peninsula of California; where, according to Vanegas in his history, published about 100 years ago, the fruit of a great Cactus forms an important article of food to the natives of the eastern coast, the harvest time of which was a season of great festivity. The flowers are produced in May and June, and the fruit ripens in July and August. Mr. Thurber collected the last flowers and the first ripe fruit in the beginning of July. He has collected abundance of seed, and will be pleased to communicate it to those who take an interest in the cultivation of Cacti. The youngest plants Mr. Thurber noticed were three or four feet high, with narrow furrows and long spines; the smallest flowering plants were about 12 feet high, and the tallest specimens observed appeared to reach the elevation of 45 or 50 feet.

The ligneous fascicles correspond with the intervals between the ribs, and not with the ribs themselves; of which Dr. Parry has fully satisfied himself, and which indeed is the case in all ribbed Cacti. From between these bundles ligneous fibres radiate horizontally towards the ribs, and especially to the areolæ.

At the base of the stem the ribs are broad and obtuse, with wide and shallow intervals; upwards the ribs are somewhat triangular, rounded or obtuse, with deep and acutish grooves between them; towards the top of the plant the ribs are equally obtuse, but quite compressed, and the grooves are deep and narrow.

The elevated areolæ are 7 lines long, nearly 6 lines in diameter, about an inch distant from one another, sometimes more closely approximated.

Lowest and upper radial spines 6 to 12 lines long, sometimes the upper ones with a few additional, shorter, flexuous, setaceous spines: lateral ones 12–18 lines long, the lower ones longest; the four lower central spines straight or very slightly curved downwards, 20–30 lines long; the two upper central spines 15 to 18 lines long. The stoutest spines are one line in diameter, their bulbous base being fully twice as thick. The old spines together with the whole areola readily come off in one bunch, but generally the 6 central spines fall off first, leaving the radiating ones appressed to the stem, till finally they also fall away.

The flowers are produced near the summit of the plant, but not on it, and the fruit is usually 6–12 inches from it.

The dried flower communicated by Mr. Thurber is 3 inches long; but the drawing represents the flowers as fully 4 inches in length and diameter. The ovary in the dried specimen is ¾ths of an inch long; the lower naked part of the tube 1 inch, the upper staminiferous much widened part ¾ths of an inch long. Upper sepals fleshy, greenish white, ¾ths of an inch long, below 2, above 4 lines wide. Petals of a light cream color, an inch long, 6–7 lines wide above, very thick and fleshy, and very much curled. Filaments light yellow, adnate to the upper half of the tube: anthers 0·8 to 0·9 of a line long, linear, emarginate at the base and apex. Style not seen; the drawing represents the numerous (15–20?) stigmata as half an inch long, suberect, of a green color. The flowers appear to be open night and day, and probably for several days in succession.

The fruit sent by Mr. Thurber (in alcohol) is obovate 2½ inches long, by 1½ in diameter, beset with about thirty scales, having short brownish wool in their axils, but entirely destitute of spines. Mr. Thurber informs me that this specimen is unusually long: the fruit, he says, is usually 2 or 3 inches long by 1½ to 2 in diameter; the color is green, reddish towards the summit; the remains of the flower fall off, leaving a broad and convex scar. The pericarp has the hardness of a green cucumber, somewhat softer towards the apex, and is about 2 lines thick: it bursts open on the plant with 3 or mostly 4 irregular, interiorly red valves, which spread horizontally, and appear like a red flower when seen at a distance, which accounts for the report of this species having red flowers. The crimson-colored and rather insipid pulp has the consistency of a fresh fig; it completely separates from the rind, and drying up from the heat of the sun, falls to the ground, or is beaten down, when it is collected by the natives and rolled into balls, which keep several months, or is pressed for the thick molasses-like sacharine juice which it contains. The innumerable seeds are 0·7 to 0·8 lines long.

Another, apparently nearly allied species, was collected in Northern Sonora. From the half of a flower before me, together

with Mr. Thurber's meagre notes, (other specimens unfortunately having been lost,) I have ventured to make out the following description:

Cereus Thurberi (n. sp.): erectus, elatior, e basi ramosus sub-14-costatus, sulcis parum profundis, aculeis brevibus nigricantibus; floribus tubuloso-campanulatis virescenti-albidis; ovario globoso sepalis 80–100 carnosis squamiformibus triangularibus acutis imbricatis ad axillam villosis stipato; sepalis tubi inferioribus 24 lanceolatis acutiusculis axilla nudis, superioribus 20–25 orbiculato-obovatis obtusis; petalis 16–20 obovato-spathulatis obtusis crassis.

Collected in June 1851, in a rocky cañon near the mountain pass of Bacuachi, a small town on the road to Arispe, in Sonora; afterwards found with *Cereus giganteus*, near Santa Cruz: it abounds also near Magdalena and Ures. Santa Cruz appears to be the northern limit of this species, which does not extend to the Gila river. Stems 4 to 12 feet high, many from the same base, 6 to 10 inches in diameter, sometimes articulated, occasionally branching above, with about 14 ribs and shallow grooves. Flowers greenish white, borne about a foot below the summit of the stem. Dried flower $2\frac{3}{4}$ inches long; the tube narrower, and more elongated than in *C. giganteus;* the globose ovary and the naked and staminiferous part of the tube each about $\frac{3}{4}$ inch long; free part of petals of the same length, and 4 lines wide. Anthers much larger than in the foregoing species, 1·3 to 1·4 lines long. Style not seen.

I have dedicated this to the collector, Mr. George Thurber, of Rhode Island, an excellent botanist, who has kindly furnished me with the materials for this article.

Cereus Thurberi and *C. giganteus* appear to be closely allied species. They have high and erect stems, flowers with a short tube, half of which is naked, the filaments occupying only the upper half of the tube; both have short and fleshy sepals on the ovary, with short wool in their axils, unaccompanied by any bristles or spines; in both the petals are whitish, obtuse, and fleshy.

Both, and especially *C. giganteus*, stand very near the *Pilocerei* on account of the great height of the stem, the short ventricose tube of the flower, and the thick petals; but they have not the least indication of a *cephalium* (or woolly head) nor of any particular development of wool; their flowers spring from the axils of the ordinary and unaltered areolæ; and the seed is quite different, at least from that of *Pilocereus senilis*, the only species of that genus, I believe, which has been well examined; these seeds are said to be obliquely thimble shaped, densely dotted, and to have an embryo with thick globose cotyledons. It is also said that the filaments cover the whole inside of the tube of the flower,

and even the free upper part of the ovary. In all the *Cerei* and *Echinocacti* examined by me, I find the lowest part of the tube free, the filaments being adnate to some distance above the ovary. It is not improbable that the Chilian velvety *Cerei* (*Velutini*, Pr. Salm.) are to be classed near our species. The flower of what appears to be *Cereus Chilensis*, Pfr., obtained near Valparaiso, and figured by the artist of the U. S. Exploring Expedition, greatly resembles that of *C. Thurberi:* it is a little larger, but has the same shape, and the same closely imbricated sepals on the ovary; the tube has about 100 sepals, and the white petals are acute; whether fleshy or not is uncertain.

ART. XXIV.—*On the Chemical Composition of Recent and Fossil Lingulæ, and some other Shells;* by W. E. LOGAN, F.R.S., and T. S. HUNT.

IN the Report of Progress of the Geological Survey of Canada for 1851–52, we have mentioned the existence of small masses containing phosphate of lime, and having the characters of coprolites, which occur in several parts of the Lower Silurian rocks. In a bed of silicious conglomerate towards the top of the calciferous sandstone, at the Lac des Allumettes, on the Ottawa, they are abundant in cylindrical and imitative shapes, sometimes an inch in diameter. The same material forms casts of the interior of a species of Holopea or Pleurotomaria, and often fills or completely incases the separated valves of a large species of Lingula, which Salter has referred to *L. parallela* of Phillips. The phosphatic matter is porous, friable, and of a chocolate brown color; it contains intermixed a large quantity of sand; and small pebbles of quartz are sometimes partly imbedded in it. The analysis of one specimen gave 36 per cent. of phosphate of lime, with 5 p. c. of carbonate and fluorid, besides some magnesia and oxyd of iron, and 50 p. c. of silicious sand.

Similar masses occur in the same formation at Grenville, and in the lower part of the Chazy limestone at Hawkesbury, in both cases containing fragments of Lingula. Those from the latter place, are rounded in shape, and from one-fourth to one-half of an inch in diameter, blackish without, but yellowish-brown within, and having an earthy fracture; the analysis of one of them gave:

Phosphate of lime, (PO_5, 3CaO), -	44·70
Carbonate of lime, - - - -	6·60
Carbonate of magnesia, - - -	4·76
Peroxyd of iron, and a trace of Alumina,	8·60
Insoluble silicious residue, - - -	27·90
Volatile matter, - - - - -	5·00
	97·56

From the color it is probable that the iron exists as a carbonate. When heated in a tube, a strong odor like burning horn is perceived, accompanied by ammonia which reddens turmeric paper and gives white fumes with acetic acid, showing that a part at least of the volatile matter is of an animal nature. The specimens from Lac des Allumettes lose 1·7 p. c. by gentle ignition, with a like production of ammonia, and an odor of animal matter; the same thing was observed with those from Grenville.

The existence in Lower Silurian rocks, of these masses, whose characters leave no doubt that they are coprolites, and whose chemical composition is like that of the excrements of creatures feeding upon vertebrate animals, led us to examine the shells of the Lingulæ always associated with these phosphatic bodies. The result has been that all the specimens yet examined consist chiefly of phosphate of lime; they dissolve readily with slight effervescence in hydrochloric acid, and the solution gives with ammonia a copious precipitate readily soluble in acetic acid, from which oxalic acid throws down lime. With a solution of molybdate of ammonia there is obtained a quantity of the characteristic yellow molydo-phosphate, many times greater than the bulk of the shell.

We have thus examined *Lingula prima*, and *L. antiqua*, from the Potsdam sandstone, *L. parallela* from the calciferous, and a species somewhat resembling *L. quadrata*, from the Trenton limestone. It was desirable to compare with these, the shell of a recent species, and for this purpose, fine specimens of the *Lingula ovalis*, of Reeve, from the Sandwich Islands, were furnished us by J. H. Redfield, Esq. of New York. The shell of this species had the same composition as the fossil ones, and the thick green epidermis, which swelled up like horn when heated, gave a bulky white ash of phosphate of lime.

For a further analysis the shell was boiled in water to remove all soluble matters, the soft parts still adherent were carefully detached, and the shell with its epidermis weighing ·186 grammes, was calcined over a spirit lamp. The brownish residue weighing ·114 grammes, readily dissolved with slight effervescence, in dilute hydrochloric acid, leaving but a few light flakes of carbonaceous matter. Acetate of soda and perchlorid of iron were added to the solution, which was boiled, and the precipitated basic salt separated by filtration, and decomposed by hydrosulphuret of ammonia. The filtrate from the sulphuret of iron having been concentrated, the phosphoric acid was thrown down by ammonia with a magnesian salt; there was obtained ·070 grms. of pyrophosphate of magnesia, equal to ·044 of phosphoric acid, or ·0978 of phosphate of lime, $PO_5, 3CaO$.

The lime was separated from the acetic filtrate, as an oxalate, and gave ·108 of carbonate, equal to ·0605 of lime, being an ex-

cess of ·0075 over the amount required to form the phosphate, and corresponding to ·0134 of carbonate; the small amount of material did not permit us to determine whether a portion of the lime exists as fluorid. There was also obtained ·0032 of magnesia; the results from the calcined shell of *Lingula ovalis* are then as follows:

Phosphate of lime,	·0978	=	85·79 p. centum.
Carbonate of lime,	·0134	=	11·75
Magnesia, - -	·0032	=	2·80
	·1144	=	100·34

The proportion of phosphate of lime is that contained in human bones, after their organic matter has been removed.

The texture of the ancient Lingulæ was observed to be unlike that of most other fossil shells, being more or less dark brown in color, brilliant, almost opaque, and not at all crystalline. These characters are also found in the allied genus *Orbicula*, and we therefore examined an undescribed species of it, from the Trenton limestone, beautifully marked in a manner resembling *Conularia granulata*, and another large species also undescribed, from the Upper Silurian; both of these consist chiefly of phosphate of lime; and the shell of a recent species *O. lamellosa* from Callao, was found to be similar in composition. We have not yet been able to examine a specimen of the genus *Obolus*. The same dark color and brilliancy were also remarked in the genus *Conularia*, and the shell of *C. trentonensis*, proved on examination to be composed in like manner of phosphate.

The similarity of composition in these genera is in accordance with the acute observations of Mr. Hall, who finds that *Conularia* is almost always associated with *Lingula* and *Orbicula*, and remarks that "these shells so unlike in structure and habit, appear to have flourished under similar circumstances, and to have required the same kind of ocean bed or sediment."—Palæontology, vol. i, p. 101.

For the sake of comparison, we have examined the following fossil shells: they have a common character, distinct from those already described, being lighter colored, more translucent and granular in texture; *Atrypa extans*, *Leptæna alternata*, and *Orthis pectenella* from the Trenton limestone; *O. enatica* from the Hudson River group, and *Chonetes lata ?* from the Upper Silurian, besides *Isotelus gigas*, and a species of *Cythere* from the Trenton. All of these consist of carbonate of lime, with only such traces of phosphate as are generally found in calcareous shells.

In the Report already quoted we have given a description of some phosphatic bodies which resemble the coprolites of the Calciferous sandstone, and are found at Rivière Ouelle in thin layers of a conglomerate limestone, which is interstratified with

red and green shales, and belongs to the top of the Hudson River group or the base of the Oneida Conglomerates. The phosphatic masses are very abundant, and rounded, flattened, or cylindrical in shape, and from one-eighth of an inch to an inch in diameter; they sometimes make up the larger part of the conglomerate. Iron pyrites in small globular masses occurs abundantly with them, often filling their interstices, but is not found elsewhere in the rock. These coprolites are finer grained and more compact than those from the Ottawa, and have a conchoidal fracture; their color is bluish or brownish black; the powder is ash-grey, becoming reddish after ignition. They have the hardness of calcite and a density of 3·15. When heated they evolve ammonia with an animal odor, and with sulphuric acid give the reactions of fluorine. The quantitative analysis of one gave—

Phosphate of lime, $PO^5, 3CaO$, -	40·34 p. c.
Carbonate of lime, with fluorid, -	5·14
Carbonate of magnesia, - -	9·70
Peroxyd of iron with a little alumina	12·62
Oxyd of manganese, - - -	*trace*
Insoluble silicious residue, - -	25·44
Volatile matter, - - - -	2·13
	95·37

The iron exists in part at least as carbonate, and its introduction in so large a quantity, giving color and density to the coprolites, is doubtless connected with the formation of iron pyrites by the de-oxydizing action of organic matters. The production of an equivalent of bisulphuret of iron, from a neutral protosulphate of iron, which alone could exist in contact with limestone, must be attended with the elimination of an equivalent of protoxyd of iron; for $2(SO_3 . FeO) - O_7 = FeS_2 + FeO$.

It is remarkable that no traces of Lingulæ or any other shells have been detected with these coprolites. Thin sections of them are translucent, and under the microscope are seen to consist of a fine granular base, in which are imbedded numerous grains of quartz, and small silicious spiculæ, like those of some sponges. In a bed of sandstone, associated with these conglomerates and slates at Rivière Ouelle, were found several hollow cylindrical bodies, resembling bones in appearance. The longest one is an inch and a half long, and one-fourth of an inch in diameter. It is hollow throughout, and had been entirely filled with the calcareous sandstone, in which it is imbedded, and whose disintegration has left the larger end exposed. The smaller extremity is cylindrical, and thin, but it gradually enlarges from a thickening of the walls, and at the other end becomes externally somewhat triangulariform; the cavity remains nearly cylindrical, but the exposed surfaces are rough and irregular within.

The texture of these tubes is compact, their color brownish black with a yellowish brown translucency in thin layers. Analysis shows them to consist, like the coprolites, principally of phosphate of lime. One hundred parts gave,

Phosphate of lime, - - - -	67·53
Carbonate of lime, - - - -	4·35
Magnesia, - - - - -	1·65
Protoxyd of iron, - - - -	2·95
Insoluble silicious sand, - - -	21·10
Volatile, animal matter, - - -	2·15
	99·73

The microscopic examination of a section, shows that the walls of the tube are homogeneous, unlike the coprolites, and that the silicious sand in the analysis, came from the sandstone which incrusted the rough interior of the fossil. The phosphate is finely granular and retains no vestige of organic structure. The chemical composition and the remarkable shape of the specimens however, leave little doubt of their osseous nature, unless we suppose them to be the remains of some hitherto unknown invertebrate animal, whose skeleton, like those of Lingula, Orbicula and Conularia, consisted of phosphate of lime, a composition hitherto supposed to be peculiar to vertebrate skeletons.

Montreal, Jan. 5th, 1854.

Art. XXV.—*On a new Meteorite from New Mexico;* by Dr. F. A. Genth, of Philadelphia.

I am indebted to Prof. Joseph Henry, Secretary of the Smithsonian Institution, for a small piece of an interesting meteorite from New Mexico. It was labelled "Native Iron," and is said to occur there in large quantities. Fortunately it was just sufficient for an examination, the results of which I here give. There is no doubt that the mineral is of meteoric and not of telluric origin.

It is very crystalline and shows a distinct octahedral cleavage. Its color is iron-gray, its lustre metallic. Quite ductile. Sp. gr. (at 18° Cels.) = 8·130.

Dissolves readily in diluted nitric acid, leaving a small quantity of insoluble residue—which, however, was also slowly dissolved by strong nitric acid or aqua regia, but still more easily by fusion with bisulphate of potash.

The methods used for its analysis were the following: In analysis I, the meteorite was dissolved in strong nitric acid; nickel and cobalt were separated from iron by carbonate of baryta; nickel and cobalt were separated by hydrocyanic acid, potash and oxyd of mercury.

In analysis II, the meteorite was dissolved in diluted nitric acid, and the residue filtered off on a weighed filter. In the filtrate iron was separated from cobalt and nickel, by addition of a sufficient quantity of acetate of potash, in order to convert the nitrates into acetates, and evaporation to dryness in a water-bath. The dry mass was boiled with water and filtered. From the filtrate, which contained the whole quantity of oxyds of cobalt and nickel, these were precipitated by caustic potash. The precipitate of sesquioxyd of iron was re-dissolved in hydrochlorid acid, and precipitated by ammonia. This method gives excellent results, if used with care. The only objection might be, that the sesquioxyd of iron, thus separated, is difficult to filter.

The insoluble residue was ignited and fused with bisulphate of potash. On treating the fused mass with water, a white substance of the appearance of tartaric acid remained, which hydrochloric acid slowly dissolved. This substance and sesquioxyd of iron were precipitated by ammonia, and from the filtrate, oxyd of nickel separated as usual. The precipitate was weighed, dissolved in hydrochloric acid, and the iron precipitated by sulphid of ammonium, after the addition of tartaric acid and ammonia. From the sulphid of iron, the iron was determined as usual. From the filtrate, the other substance remained after the tartaric acid was destroyed by heat. It was, however, a very small quantity, and only sufficient for *one* blowpipe reaction. The borax bead gave in the inner flame an enamel of a bluish color. I therefore believe that it is tartaric acid, though the reactions somewhat differ.

The insoluble residue seems to be a combination of Iron, Nickel and Titanium. It contains *no* cobalt. Neither part of the meteorite contained carbon, sulphur, phosphorus or tin.

	I.	II.
Iron,	= 96·17	95·92
Nickel,	= 3·07	3·57
Cobalt,	= 0·42	
Insoluble,	= ——	0·57
	99·66	100·00

The insoluble part consisted of a steel-colored powder in microscopic crystals, which showed three-sided planes. Its composition is:

Iron,	= 55·07 p. c.
Nickel,	= 28·78
? Titanium,	= 16 15
	100·00

It is remarkable that the elements in the insoluble part are in the following ratio:

Fe : Ni : ? Ti = 6 : 3 : 2.

Art. XXVI.—*Introductory Essay, in Dr. Hooker's Flora of New Zealand:* Vol. I.*

Dr. J. D. Hooker, the Botanist of the Antarctic Expedition under Capt. Sir James C. Ross, on his return to England—combining with his own extensive collections and observations all the accessible materials which have been accumulating in herbaria ever since the first voyage of Capt Cook—courageously assumed the task of preparing general floras of the three principal masses of southern land, in which his researches were made; viz., Antarctic America, New Zealand, and Tasmania. The first of these undertakings was accomplished several years since, in the publication of the *Flora Antarctica;* including Antarctic America with the Falkland Islands, the Campbell and Auckland Islands (properly pertaining to the New Zealand region), and the remote Kerguelen's Land. Some abstracts were given in this Journal at the time, from parts of the work possessing a general interest.

The recent completion of the fourth fasciculus, and first volume, of the second work, viz.: the *Flora Novæ Zelandiæ*, comprising all the Flowering plants of that group of islands, affords our author an opportunity to discuss, in an introductory essay, some topics of high interest to the philosophical naturalist; topics upon which his aptitude for such investigations, and the unparalleled opportunities of observation which he has enjoyed, and improved to the utmost, in almost every clime, must needs give no small weight to his opinions. Deeming as we do this essay to be an important and timely one, we propose to make a somewhat extended analysis of it, leaving out of view for the present the body of the work, as interesting to the systematic botanist alone.

In the Essay in question (occupying 39 quarto pages), Dr. Hooker gives, 1. The History of New Zealand Botany, and the probable limits of its flora. 2. An exposition of the views adopted in the descriptive part of the work, as to the affinities, limits, origin, variation, distribution, and dispersion of plants generally. 3. The illustration and development of these points by an analysis of the New Zealand Flora, and its relation to that of other countries.

The history of the Botany of New Zealand, from the visit of Sir Joseph Banks and Dr. Solander, during Capt. Cook's first voyage, in 1790, down to the present time, need not arrest our attention. The actual number of species inhabiting these islands is a matter which it would be interesting to know, even approximately. Dr. Hooker has brought together about 2,000 species in

* The Botany of the Antarctic Voyage of H. M. Discovery Ships Erebus and Terror, in the years 1839—1843, under the command of Capt. Sir James Clark Ross; by Joseph Dalton Hooker, M.D., etc. etc. II. Flora Novæ-Zelandiæ, Part I. Flowering Plants. London. Lovell Reeve, 1852–1853. pp. 312, 4to, tab. 70.

his Flora, including upwards of a hundred of the lower Cryptogamia of which the materials are in too imperfect a state for satisfactory determination. This is more than double the number comprised in the latest preceding catalogue, that of M. Raoul, "who in 1846 enumerates only 920 species; which may be reduced to 770, if the naturalized and erroneous species be eliminated." "In 1838, Mr. Cunningham gave 640 species, which should be reduced to 570: in 1832, M. Richard included 350 in his list: Forster's Prodromus has 154; and Banks' and Solander's collections amount to 426. This rapid increase of the flora, which has thus been quintupled in twenty years, is mainly due to the attention which has been devoted to the lower orders. This may be easily shown; for, whereas in all the earlier enumerations and collections the number of Flowering plants exceeds the Flowerless, in M. Raoul's catalogue they are equal, and in the present work the relative proportions are reversed; the Phænogamic plants being to the Cryptogamic as 1 to 1·6, i. e. about two to three." As to the probable ratio of the known materials to the whole flora, Dr. Hooker remarks that "the islands have been botanized upon by upwards of 35 individuals, whose specimens have (with a few unimportant exceptions) all passed under my eye. The flora of the Northern Island has been tolerably well examined, so far as its flowering plants are concerned; though there remains a good deal to be done on the west coast, especially in the neighborhood of Mount Egmont. Dr. Lyall alone has collected on the Southern Island, and on the west coast north of Dusky Bay. The Middle Island has been visited by few explorers; its north and east coasts alone having been botanized: the west, and the whole mountain range require a careful survey; and, considering how many Auckland and Campbell Islands' plants are still strangers to New Zealand, it cannot be doubted that much remains to be discovered there. Excepting from the above mentioned tracts, I do not expect much novelty among Flowering plants, for the following reasons: 1. There is a remarkable sameness in the flora throughout large tracts, (in which respect New Zealand contrasts remarkably with Tasmania); 2. Because out of the 730 flowering plants known, there are scarcely one hundred that have not been gathered by several individuals; 3. Because the collections I have lately received, though some of them are extensive, and from scarcely visited localities, yet contain little or no novelty. With Cryptogamia the case is widely different; and it is difficult to estimate the vast number, especially of Mosses, Hepaticæ, and Fungi, that will reward future explorers in what, as far as Flowering plants are concerned, are exhausted fields." From the data now possessed, and from a comparison of the same with the flora of better known countries, Dr. Hooker ventures the opinion that there are not more than 4000 species in

New Zealand, of which 1000 may be Flowering plants. "Compared with any other countries in the same latitude, this is a very scanty flora indeed, especially as regards Flowering plants; of which Britain contains, in about the same area, upward of 1,400 species; and in Tasmania, not yet well explored, and containing only one-third of the area, upwards of 1000 have already been discovered. In Cryptogamous plants, on the other hand, these islands are extremely rich, not only proportionately to the Phænogamic, but absolutely so. Great Britain, where the lower orders have been assidously studied for fifty years, contains about 50 Ferns, and Tasmania 64;" while Dr. Hooker's list of New Zealand Ferns (including Lycopodiaceæ), after reducing almost half as many nominal species to more varieties, contains upwards of 114 species. The same result would appear all the more strikingly on a comparison with any equivalent *continental* tract in the northern hemisphere. In all British America and Oregon only 62 species of Ferns and Lycopodiaceæ are recorded.

Dr. Hooker's second chapter, on the limits of species, their dispersion and variation, deals with matters of higher general interest. To bring the points in question fairly into view, he assumes four positions as heads of the subjects upon which he proceeds to discourse, namely:

"1. That all the individuals of a species (as I shall attempt to confine the term) have proceeded from one parent (or pair), and that they retain their distinctive (specific) characters.

2. That species vary more than is generally admitted to be the case.

3. That they are also much more widely distributed than is usually supposed.

4. That their distribution has been effected by natural causes; but that these are not necessarily the same as those to which they are now exposed."

The first of these propositions should have been divided into two:—inasmuch as the first clause is not only open to some very specious if not cogent objections which do not apply to the others, but is from its very nature incapable of being supported by the kind of evidence which may sustain the other propositions. The fact that we constantly see like individuals reproduced, and under favorable circumstances increased, from a parent stock, lays, indeed, a solid ground for the inference that this process has been going on from the beginning: but how things go on, and how they began, are two different questions; and it is seldom, if ever, that the facts and deductions which account for the former, can be made to throw much *direct* light on the latter. Why is it not antecedently just as probable that several or many individuals of each species of plant, as identically like each other as are the offspring to the parent now, were created at the beginning, as

that each began with a single pair? We would still maintain that the objective idea of species arises from this "perennial succession of like individuals (to use the phrase of Linnæus), sustaining to each other the relation of parent and progeny; and we think that the evidence on that side of the question strongly favors the inference, that plants, at least, have been distributed each species from a single and specific primordial area: but we know not what scientific evidence makes it needful to maintain the doctrine of the single creation of species in the restricted form of a single initial individual or pair. Were we even to go so far as explicitly to assume the likelihood, in certain cases, of the original creation of numerous individuals of a species, all alike in character, we could not be charged with infringing the rule that no more causes should be assumed than are requisite to ensure the result; since—to say nothing of the imminent risk of the premature destruction of a single individual—in many cases both of animals and vegetables, a considerable number would be required at the outset to fulfil the relations established between the individuals, either of the same or of different species. It would be more satisfactory, therefore, because less hypothetical and more within the reach of evidence, if the proposition were stated in the more general form; viz., that all the individuals of a species have proceeded from a common stock, assigned to a limited primordial area;—in which form its bearing upon the other propositions would not be altered. Indeed, Dr. Hooker expressly states, in the commencement of his remarks upon the first proposition, that he lays no stress upon that particular hypothesis, nor does he advance any arguments in support of it. The whole section is, in fact, mainly devoted to the illustration of the second clause, namely, that species retain their distinctive characters from age to age. As the section can hardly be abridged without injury, we extract a large portion of it. After stating various views that are maintained in respect to the origin or development of species, the author proceeds:

"Arguments in favor of these views are not wanting, derived both from the animal and vegetable kingdoms; the chief of which are drawn from a large class of well established facts, upon the bearings of which the most distinguished and candid naturalists are divided in opinion: such are—the great number of genera whose species have baffled all attempts at circumscription by fixed characters,—the facility with which breeds of certain plants and animals may be propagated, and the comparative certainty with which some few varieties are reproduced under favorable circumstances,—the great facility with which many plants hybridize, and the facts of hybrids having proved fertile,—the sudden appearance and unexplained cause of many varieties or sports,—and the difficulty of accounting for the existence of plants and animals in two or more localities, between which they cannot have been

transported by natural causes now in operation. These are all questions relating to the diffusion and variation of species, which will be discussed here and in the following section.

Arguments in favor of the single creation, and permanence of species, are all based upon general considerations of the phenomena of distribution. Comparative anatomy, which has thrown so great light upon this branch of study in the sister kingdom, has not done so much for plants; this arises from several causes: 1. The habits of allied plants do not differ so remarkably as those of animals, and there is consequently less modification of their functional organs. 2. The relation of these modifications to the habits and wants of the species, is in the animal kingdom directly appreciable, but in plants no such connection can be traced.* 3. The individual organs of support, respiration, and reproduction, are infinitely more variable and susceptible of change and even obliteration in plants, without affecting the life either of the individual or of the species.† The result of these facts is that we have the means in animals of appreciating the extent and value of differences, by combined observations upon structure and functions, upon habits and organization, which we have not in the vegetable kingdom, and which the phenomena of cultivation assure us do not exist to a degree that has, within the limits of our experience, proved available for throwing much light on the subject.

The arguments in favor of a permanence of specific characters in plants are:—

1. The fact that the amount of change produced by external causes does not warrant our assuming the contrary as a general law. Though there are many notorious cases in which cultivation and other causes produce changes of greater apparent value than specific characters generally possess, this happens in comparatively very few families, and only in such as are easily cultivated. In the whole range of the vegetable kingdom, it is difficult to produce a change of specific value, however much we may alter conditions; it is much more difficult to prevent an induced variety from reverting to its original state, though we perse-

* The structure of woods offers many illustrations of this; very closely allied plants (especially *Leguminosæ*) differing entirely in the nature, arrangement, and development of the vascular and cellular tissues of their trunks. Though to a great extent these differences accompany a habit of growth (as in the case of erect and scandent *Bauhinias*), there is nothing in the abnormally developed wood of the climbing *Bauhinia* that would lead a skilled physiologist ignorant of the fact to say that it was better adapted to a climbing than to an erect plant; the function is experimentally known to be indicated by the structure, but the structure is not seen to be adapted to the function. This is not so in the sister kingdom, for we confidently pronounce an animal to be a climber, because we see that its organs are adapted to the performance of that function; here the habit is not only indicated by the structure but the latter is explained by the function which it enables the animal to fulfill.

† To take an extreme case of this;—many plants are known, in a wild and cultivated state, which propagate abundantly by root or division, where they do not do so by seed. *Anacharis Alsinastrum* is a conspicuous example: it is a unisexual water-plant, of which one sex alone was introduced from North America into England, where it has within a few years so spread by division as to be a serious impediment to inland navigation. The Horse-radish is another example, it being, I believe, never known to seed or even to bear perfect flowers. A still more remarkable case has been pointed out to me by Mr. Brown, in the *Acorus Calamus*, a plant spread (not by cultivation) over the whole north temperate hemisphere, which bears hermaphrodite flowers, but very rarely seeds.

vere in supplying the original conditions; and it is most difficult of all to reproduce a variety with similar materials and processes.*

2. In tracing widely dispersed species, the permanence with which they retain their characters strikes the most ordinary observer; and this, whether we take such plants as have been dispersed without the aid of man (as *Sonchus oleraceus*, *Callitriche*, and *Montia*) through all latitudes from England to New Zealand; or such as have within modern times followed the migrations of man (as *Poa annua*, *Phalaris Canariensis*, Dock, Clover, *Alsine media*, *Capsella bursa-pastoris*, and a host of others); or such as man transports with him, whether such temperate climate plants as the cerealia, fruits, and flowers of the garden or field, or such tropical forms as *Convolvulus Batatas* and yams, which were introduced into New Zealand by its earliest inhabitants;—all these, in whatever climate to which we may follow them, retain the impress of their kind, unchanged save in a trifling degree.

3. With comparatively few exceptions, plants are confined within well-marked limits, which, though often very wide, are sometimes as much the reverse; while the instances are rare of sporadic species, as such are called which are found in small numbers in widely sundered localities. These facts seem incompatible on the one hand with the theory of species spreading from many centres, and on the other with their varying indefinitely; for were it otherwise, sporadic distribution would be the rule, insular floras would not necessarily be peculiar, and similar climates would have similar, if not identical species, which is not the case.

4. A multitude of allied species of plants grow close together without any interchange of specific character; and there are instances of exceedingly closely allied plants keeping company under many modifications of climate, soil, and elevation, yet never losing their distinctive marks.

5. The individuals that inhabit the circumference of the area occupied by a species, are not found passing into other species, but ceasing more or less abruptly; their limits may meet or overlap those of one or more very similar species; when the individuals associate, but do not amalgamate.

6. One negative argument in favor of distribution from one centre only, is, that taking the broadest view of the dispersion of species, we find that the more extensive families† are more or less widely distribu-

* I am quite aware that this argument will be met by many instances of change produced in our garden plants: but, after all, the skill of the gardener is successfully exerted in but few cases upon the whole: out of more than twenty thousand species cultivated at one time or another in the Royal Gardens of Kew, how few there are which do not come up not only true to their species, but even to the race or variety from which they spring; yet it would be difficult to suggest a more complete change than that from the Alps or Polar regions to Surrey, or from the free air of the tropics to the thoroughly artificial conditions of our hot-houses. Plants do not accommodate themselves to these changes: either they have passive powers of resisting their effects to a greater or less degree, or they succumb to them.

†This rule does not extend to the Natural Orders themselves. The *Compositæ*, whose facilities for dispersion are proverbial, are amongst the most local; and the same may be said of *Leguminosæ* and *Solaneæ*, whose seeds retain their vitality in a remarkable degree: a few of their species are remarkably cosmopolite, but the greater number have generally narrow ranges.

*ted, very much in proportion to the facilities they present for disper-*sion. Thus the most minute-spored Cryptogams* are the most widely dispersed of all organized nature; plants that resist the influence of climate best, range furthest; water-plants are more cosmopolite than land-plants, and inhabitants of salt, more than those of fresh water: the more equable and uniform is the climate of a tract of land, the more uniformly and widely will its plants be distributed.

7. The species of the lowest orders are not only the most widely diffused, but their specific characters are not modified by the greatest changes of climate, however much their stature and luxuriance may vary. Fungi offer a remarkable instance of this: their microscopic spores are wafted in myriads through the air; the life of the individuals is often of very short duration, and many of them being as sensitive as insects to temperature and humidity, they are ephemeral in all senses; sometimes appearing only once in the same spot, and remaining but a few days, never to reappear within the observer's experience. The specific characters of many reside in the diameter, form, color, and arrangement of their most minute organs, whose analysis demands a refinement of microscopic skill; yet the most accomplished and profound botanist in this Natural Order (who has favored me with the descriptions of the New Zealand Fungi) fails to find the most trifling character by which to separate many New Zealand species from European.

8. The fact, now universally conceded by all intelligent horticulturists, that no plant has been acclimated in England within the experience of man, is a very suggestive one, though not conclusive; for it may be answered, that plants which cannot survive a sudden change, might a slow and progressive one. On the other hand, plants have powers of enduring change when self-propagated that they have not in our gardens; thus I find a great difference in the hardiness of individuals of several Himalayan plants,† depending upon the altitude at which they were gathered. In these cases the species is the same, and the parent individuals were not even varieties of one another, except so far as regards hardiness; in other words, the specific character remains unaltered in spite of the change of constitution, just as the climate of one part of the globe disagrees with the human race of another, and is even fatal to it.

Such are a few of the leading phenomena or facts that appear to me to give the greatest weight to the opinion that individuals of a species are all derived from one parent: for such arguments as the New Zealand Flora furnishes, I must refer my readers to the following chapter. I would again remind the student that the hasty adoption of any of these theories is not advisable: plants should be largely collected, and

* The fact (first communicated to me by the Rev. M. J. Berkeley) of the spores of Fungi having been found by Professor Ehrenberg mingled with the atmospheric dust that has fallen on ships far out at sea, is one of the most decisive proofs of this.

† Thus some of the seedling Pines whose parents grew at 12,000 feet appear hardy, whilst those of the same species from 10,000 are tender. The common scarlet *Rhododendron* of Nepal and the Northwest Himalaya is tender, but seedlings of the same species from Sikkim, whose parents grew at a greater elevation, have proved perfectly hardy.

studied both in the living and dried states, and the result of their dissection noted, without reference to any speculations, which are too apt to lead the inquirer away from the rigorous investigation of details, from which alone truth can be elicited. When however the opportunity or necessity arises for combining results, and presenting them in that systematic form which can alone render them available for the purposes of science, it becomes necessary for the generalizer to proceed upon some determinate principles."

The considerations here adduced bear partly in favor of the single creation of species of plants, partly on their permanence of specific characters from age to age; which are different questions, although closely connected. In respect to the first, we have the mere statement of the nature and kind of evidence that is available for the support of that doctrine: for its application to a particular flora, by which its amount and weight may be tested, we are referred to a subsequent portion of the essay. So, likewise, as to the permanence of species, our general conclusions must needs depend upon a knowledge of the limits within which the same species may vary; a topic which is discussed in the following section, mainly in view of its practical botanical applications. It were well that the considerations on which the doctrine of the single, as opposed to the double or multiple, origin of species rests, should be succinctly presented at one view, that their value may be estimated. For it is obvious that the very establishment of Dr. Hooker's second and third propositions may react powerfully upon the first. If species generally are much "more widely diffused than is usually supposed," then the theory of the double or multiple origin of species, as maintained by Schouw and others, becomes all the more likely, at least until adequate natural means of dispersion are clearly shown. And if, at the same time, "species vary in a state of nature more than is usually supposed," while what we term their specific characters are permanent, though the amount and value of these characters differs greatly in different species, then it may with the more probability be supposed that many of these differences were aboriginal. And these two inferences, taken together, would perhaps necessitate the conclusion, maintained we believe substantially by Prof. Agassiz, that species are ideal, as much so as genera, and even that they may have been represented from the beginning by as many individuals, and distributed over as wide an area, as at any subsequent time. A view which, by separating the idea of genetic connection from our conception of a species, seems to leave these no ground of objective reality to rest upon. We are reluctant to rest the very basis of natural history upon *a priori* conceptions, and therefore cling to the material view, that a species is not only "a primordial form" (the definition of the late Dr. Morton), but one represented in nature by the perennial succession of essentially like

individuals, which sustain to each other the relation of parent and offspring, and which, as we may actually follow them onward from generation to generation, so we may mentally trace them backward to a common and probably local stock of homogeneous individuals, if not to a single individual or pair. This furnishes a common standard to which our empirical determinations of species may be referred, and the discordant views of different describers be rendered commeasurable; as it reduces the differences to questions of the probable value of characters in each particular case. For the fact must not be overlooked, that the greater part of the species characterized in our systematic works are only provisional determinations—more or less probable conclusions from incomplete data.

Some valuable and timely remarks are to be found in the following extract:

"It is not surprising that two naturalists, taking opposite views of the value of characters, should so treat a variable genus that their conclusions as to the limits of its species should be wholly irreconcilable. Some naturalists consider every minute character, if only tolerably constant or even prevalent, as of specific value; they consider two or more doubtful species to be distinct till they are proved to be one; they limit the ranges of distribution, and regard plants from widely severed localities as almost necessarily distinct; they do not allow for the effects of local peculiarities in temperature, humidity, soil, or exposure, except they can absolutely trace the cause to the effect; and they hence attach great importance to habit, stature, color, hairiness, period of flowering, etc. These views, whether acknowledged or not, are practically carried out in many of the local floras of Europe, and by some of the most acute and observant botanists of the day; and it is difficult to over-estimate the amount of synonymy and confusion which they have introduced into the nomenclature of some of the commonest and most variable of plants. In such hands the New Zealand genera *Coprosma*, *Celmisia*, *Epilobium*, etc., may be indefinitely extended. The principles I have adopted are opposed to these: I have based my conclusions on this subject upon a very extensive examination of living plants in all latitudes, with my attention particularly directed to the influence of external causes, not only on the general phenomena of vegetation, but also upon individuals. Added to this, I have paid a great deal of attention to variable plants, both of tropical and temperate climates, and studied them in a living state, both wild and cultivated, and also in the herbarium. The result of my observations is, that differences of habit, color, hairiness, and outline of leaves, and minute characters drawn from other organs than those of reproduction, are generally fallacious as specific marks, being attributable to external causes, and easily obliterated under cultivation. It has hence been my plan to group the individuals of a genus which I assume after careful examination to contain many species whose limits I cannot define, so that the species shall have the same relative value as those have of allied genera whose specific characters are evident. In doing so I believe I have

followed the practice of every systematist of large experience and acknowledged judgment since the days of Linnæus, as Bentham, Brown, the De Candolles, Decaisne, Jussieu, Lindley, and the Richards; names which include not only the most learned systematists, but the most profound anatomists and physiologists. I am far from supposing that the same materials of a difficult group would receive precisely similar treatment at the hands of each of these eminent men; but their results would so closely approximate as to be in harmony with each other, and available for scientific purposes: with all, the tendency would be to regard dubious species as varieties, to take enlarged views of the range and variation of species, and to weigh characters not only *per se*, but with reference to those which prevail in the order to which the species under consideration belong.

In working up incomplete floras especially, I believe it to be of the utmost importance to adopt such a course, and to resist steadily the temptation to multiply names, for it is practically very difficult to expunge a species founded on an error of judgment or observation.* There is further an inherent tendency in every one occupied with specialities to exaggerate the value of his materials and labors, whence it happens, that botanists engaged exclusively upon local floras are at issue with those of more extended experience, the former considering as species what the latter call varieties, and what the latter suspect to be an introduced plant the former are prone to consider a native. There is much to be said on both sides of such questions: the local botanist looks closer, perceives sooner, and often appreciates better, inconspicuous organs and characters, which are overlooked or too hastily dismissed by the botanist occupied with those higher branches of the science, which demand a wider range of observation and broader views of specialities; and there is no doubt but that the truth can only be arrived at through their joint labors; for a good observer is one thing, and the knowledge and experience required to make use of facts for purposes of generalization, another; minute differences however, when long dwelt upon, become magnified and assume undue value, and the general botanist must always receive with distrust the conclusions deduced from a few species of a large genus, or from a few specimens of a widely distributed plant.

I have been led to dwell at length upon this point, because I feel sure the New Zealand student will at first find it difficult to agree with me in many cases, as for instance on so protean a Fern as *Lomaria procera*, whose varieties (to an inexperienced eye) are more dissimilar than are other species of the same genus. In this (and in many similar cases) he must bear in mind that I have examined many hundred specimens of the plant, gathered in all parts of the south temperate hemisphere, and have found, after a most laborious comparison, that I could not define its charcters with sufficient comprehensiveness from a

* The state of the British flora proves not only this, but further, that one such error leads to many more of the like kind: students are led to over-estimate inconstant characters, to take a narrow view of the importance and end of botany, and to throw away time upon profitless discussions about the difference between infinitely variable forms of plants, of whose identity really learned botanists have no doubt whatever.

study of its New Zealand phases alone, nor understand the latter without examining those of Australia, South Africa, and South America. The resident may find two varieties of this and of many other plants, retaining their distinctive characters within his own range of observation (for that varieties often do so, and for a very uncertain period, both when wild and also in gardens, is notorious), and he may perhaps have to travel far beyond his own island to find the link I have found, in the chain of forms that unites the most dissimilar states of *Lomaria procera;* but he can no more argue thence for the specific difference of these, than he can for a specific difference between the aboriginal of New Zealand and himself, because he may not find intermediate forms of his race on the spot. We do not know why varieties should in many cases thus retain their individuality over great areas, and lose them in others; but the fact that they do so proves that no deductions drawn from local observations on widely distributed plants can be considered conclusive. To the amateur these questions are perhaps of very trifling importance, but they are of great moment to the naturalist who regards accurately-defined floras as the means for investigating the great phenomena of vegetation; he has to seek truth amid errors of observation and judgment, and the resulting chaos of synonymy which has been accumulated by thoughtless aspirants to the questionable honor of being the first to name a species.*

There are many causes which render it extremely difficult to determine the limits of species, and in some genera the obstacles appear to increase, the more the materials for studying them multiply, and the more we follow our analysis of them into detail; hence the botanist is often led on to an indefinite multiplication of species (with increased difficulty of determining those already established), or to a reduction of all to a few, or to one variable species. My own impression is, that the progress of botany points to the conclusion that in many genera we must ultimately adopt much larger views of the variation of species than heretofore, and that the number of supposed kinds of plants is (as I shall indicate elsewhere) greatly over-estimated; if it be not so, we must either admit that species are not definable, or that there are hidden characters throughout all classes of the vegetable kingdom, of which the botanist has no cognizance, and towards the acquirement of which, if they are ever to be revealed, all efforts in the direction in which we have been advancing appear to be vain. Could systematists as a body be accused of carrying out their investigations in an unphilosophical manner or spirit, or without due attention to all the modes of testing the validity of characters, afforded by the study of living and dried plants, by direct observation, and by experiment, there might be hopes of such a revelation; but such hopes are inconsistent with the great advances that have been made in systematic botany, which, hav-

* The time however is happily past when it was considered an honor to be the namer of a plant; the botanist who has the true interests of science at heart, not only feels that the thrusting of an uncalled-for synonym into the nomenclature of science is an exposure of his own ignorance and deserves censure, but that a wider range of knowledge and a greater depth of study are required, to prove those dissimilar forms to be identical, which any superficial observer can separate by words and a name.

ing all tended to a more perfect knowledge of the affinities of plants, we are assured have been the effect of progress in the right direction."

Without doubt the preponderating tendency of the ablest and most experienced botanists of the present day is, to cancel nominal species, and, taking a more enlarged view of specific characters, to reduce slight or varying modifications to a common type; a point not yet reached by zoologists, though probably it will be hereafter. Dr. Hooker's tendency in this direction is evidently very decided; possibly too much so. But it must be allowed that, while the botanists who multiply species unduly are always those who work upon scanty materials, or whose personal observations are limited to a single district of country; on the other hand, those who have access to the largest collections, or who have themselves botanized over various parts of the world, are for the most part as strongly inclined in the opposite direction. Now Dr. Hooker possesses both these advantages in an eminent degree. Young as he still is, no living botanist has investigated on the spot so many and so widely separated floras, and few like him have had constant access to the largest and best determined herbaria in the world. The principal danger here arises from *l'embaras des richesses*. It is hardly possible that a vast series of apparently confluent forms should receive the detailed examination which the less privileged botanist may concentrate upon his fewer materials; and much is left to the quick, almost intuitive judgment, which is liable to error, indeed, but in which the true genius of a botanist is generally disclosed.

Perhaps there is no equally well known flora which compels the botanist to allow of such wide limits of variation in so large a proportion of its species, as that of New Zealand: at least so it would appear at first sight. Yet this character seems to be exhibited more or less by insular floras generally, in which a considerable number of the peculiar species are apt to be surprisingly polymorphous, as was remarked by Bory de St. Vincent half a century ago.

A. G.

(To be continued.)

ART. XXVII.—*On the relations which exist between Friction and Pressure;* by M. J. NICKLÈS.

IN preceding numbers of this Journal I have proposed for the Mechanical Arts the use of magnetic adhesion, a principle purely physical; and it becomes necessary to ascertain the relations which exist on a horizontal plane—

1. Between pressure and the friction of iron sliding on iron.

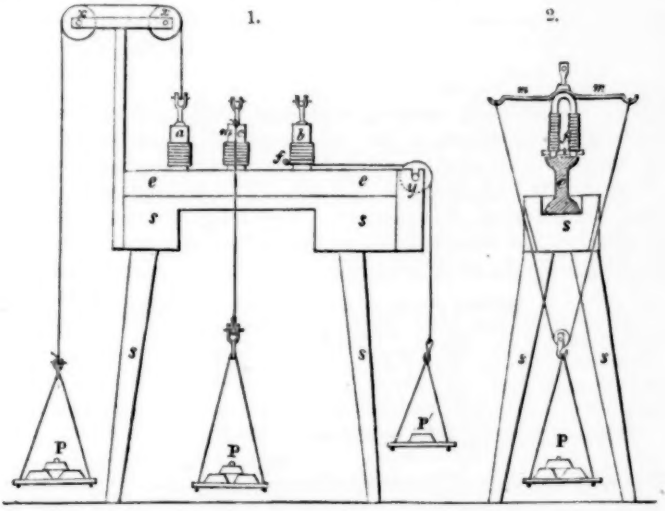
2. Between the pressure which one of these masses of iron converted into an electro-magnet exerts on the other, and the ef-

fort to overcome it in order to make this electro-magnet move on its armature.

The Treatise on General Mechanics by Morin does not mention the first relation, that of the friction of iron on iron. It is well known however, that in practice the number 0·33 is adopted for it.

I have reasons for thinking that the relation is the same in amount between magnetic pressure and the friction of sliding under this new condition. If the experiments which I have made on this subject do not prove that the friction is equal to one-third the pressure, they tend at least to establish an identity of relation between the two pressures and the two frictions. I have had occasion to recognize a like identity between the adhesion or friction of rolling under the influence of added weight alone and the adhesion or friction of rolling under the influence of magnetic attraction.*

The electro-magnet employed in the experiment was one of Joule's.† The helices consisted of 30 metres of copper wire, 2 mm. in section; each of its polar surfaces were 0·080 m. in length and 0·020 m. in breadth. They are shown in figures 1 and 2, which represent, in elevation and section, the apparatus as well as the



different phases in the experiments. The armature consisted of a piece of a railroad rail, *e*, placed level on a bar of wood, *s*; the magnet and armature had been carefully cleaned and polished.

A cord attached to the axis of the magnet was connected with a system of pulleys, *x*, *x*, and at the other extremity was attached

* See this Journal, vol. xvi, p. 337, Nov., 1853. † Phil. Mag., [4], ii, 450.

a scale for receiving the necessary weights, to determine the force of the magnetic attraction. This force, once known, the cord attached to the axis of the magnet was detached, and another was applied a little above the poles, at the height of a small pulley, *y*, fastened to the extremity of the rail: this cord which passed between the arms of the magnet terminated in a small rod of copper which was secured to *f*, on the arms, where it was held by rivets. A second scale, P′, smaller than the preceding, received the weights required for moving the apparatus onward, in the plane of the rail. The experiment was tried with a dry armature, and also with one wet with well water. To the weight carried, given in the table, 4 kilograms should be added, for the electro-magnet, and this is noted in the column of means. Moreover the horizontal sliding observed was a kilogram too great, this representing the effort to be overcome in causing the electro-magnet to slide when not magnetized, and this is deducted in the column of means. The results with the dry and wet rail are as follows:

Weight carried normally, or magnetic pressure.	Means.	Horizontal sliding.	Means.	Relations.
Dry rail, 231 k. 236 229	232+4 = 236 k.	73 k. 73 73	73−1 = 72 k.	0·30
Wet rail, 230 k. 224	237+4 = 231 k.	63 k. 67 63	64·5−1 = 63·5	0·27

The circuit being broken, a weight of 232 kil. was added to the magnet, by means of the bar *m m*, supported on the top of the magnet; the cord directly below carried a pulley to which a scale for the weights was adapted. The pressure was thus exerted normally on the magnet. The magnet itself weighed 4 kilograms; the charge was therefore 236 kil., which represents the pressure exerted on the armature in the preceding experiment.

	Normal pressure.	Means.	Horizontal sliding.	Means	Relations.
Dry rail, 236 k.	236 k.	236 k.	63 63	63	0·26
Wet rail, 236 k.	236 k.	236 k.	60 58	59	0·25

The results are hence as follows:

	Magnetic pressure.	Pressure by weight.
Relation of pressure to sliding on dry rail,	0·30	0·26
" " " wet "	0·27	0·25

It would have been interesting to have determined the amount of effort required to make the apparatus slide when both magnetized and weighted, to ascertain if the result would be the sum of the two slidings. But an accident which happened prevented the repetition of the experiments which were made in the month of January, 1851.

ART. XXVIII.—*Abstract of a Meteorologial Journal, for the Year* 1853: kept at Marietta, Ohio, in Lat. 39° 25′ N., and Long. 4° 28′ West of Washington City; by S. P. HILDRETH, M.D.

MONTHS.	THERMOMETER.						Prevailing Winds.	BAROMETER.		
	Mean temperature.	Maximum.	Minimum.	Fair days.	Cloudy days.	Rain and melted snow in inches.		Maximum.	Minimum.	Range.
January,	33·30	64	0	16	15	2·20	N., S. & S. W.	29·90	28·45	1·45
February,	37·10	64	11	12	16	4·92	N. & S. W.	29·55	28·85	·70
March,	40·66	74	14	17	14	0·88	N., S. & E.	29·70	28·80	·90
April,	53·00	80	24	17	13	5·92	N. N. E. & S.	29·55	28·75	·80
May,	61·13	88	34	16	15	3·21	S. W., S. S. E.	29·60	29·10	·50
June,	74·60	95	50	28	2	0·88	S. & S. W.	29·65	29·30	·35
July,	71·15	94	54	26	5	4·12	S. W., S. E. & N.	29·60	29·23	·37
August,	71·55	91	50	22	9	2·83	S., S. E. & N.	29·63	29·20	·43
September,	64·33	87	40	20	10	2·80	S. S. W. & E.	29·63	29·00	·63
October,	48·86	82	28	22	9	4·29	N., W. & S. E.	29·70	28·98	·72
November,	46 17	70	20	14	16	2·83	N., S. S. E.	29·83	29 20	·63
December,	31·08	62	6	12	19	2·16	N., W., N. W.	29·62	28·60	1·02
Mean for the year,	52·74			222	143	37·04				

The temperature for the year is 52°·74, which is rather above the mean annual heat for this place. No very remarkable extremes of heat or cold have distinguished the year, although the temperature in June and July was rather excessive, rising on the last day of June to 95°, being higher than for several previous years, by two or three degrees—on a number of days it was above 90°. My thermometer had a northern exposure, on the back side of the house, protected from the reflected rays of the sun by trees. At Cincinnati the degrees of heat were considerably higher, rising to 90°; and on a number of days to 95° and 96°. In New York, by the aid of reflected heat from the brick walls and stone pavements, the temperature was more elevated than in any former year; rising to above a hundred, and causing the death of a large number of persons. Heat, alone, even to 110°, is not necessarily fatal; as in the gold diggings of California, and at Mosul, in Assyria, on the river Tigris, where the American Board of Missions have several missionaries, whose health remains good with the thermometer at 112° or higher. To render it deadly, requires some imprudent act, as drinking cold water, which paralyzes the motion of the heart, by its sudden reduction of temperature. A benevolent and all-wise creator, has regulated the laws of nations in a way most beneficial to man; so that water from springs and fountains shall be of the same temperature as the mean annual heat of the climate; thus in a measure preventing the injurious effects of cold water on the over-heated human frame in the tropical regions of the earth.

The amount of rain and melted snow was $37 \cdot \frac{04}{100}$ inches—being nine and a half inches less than in the year 1852; but this is not the lowest in the scale, as it is sometimes reduced to thirty-four inches.

The Ohio river was low all the summer, commencing early in June, as we had no rain at the summer.solstice, a period when a rise in the Ohio is always expected, and seldom fails to appear. With the exception of a few feet of elevation in November, the water continued low until the setting in of winter, and closed with ice on the 25th December, when steamboats ceased running. The fall of snow was light, only about five inches near the end of the month. The lowest temperature in December, was six degrees above zero.

Winter.—The mean of the winter months was 36°·90. The coldest day was on January 29, when the mercury fell to zero. In February the lowest was 11° above. Great fluctuations of temperature occur in this month, as in 1818, the thermometer fell on one morning to 20°, and on the next to –22°; which destroyed all the peach trees in range of its influence. In, January 1851, the extreme cold being 23° below zero, killed a large portion of the bearing trees in the valley of the Muskingum; but as it was not repeated the following night, the effect was not so entirely disastrous, as some trees produced fruit in 1852, but have since died. In the latter part of January, the navigation on the Ohio was impeded by floating ice, but the river was not closed during the whole winter. There was but little snow, not more than four or five inches, and at any one time not over two inches in depth. The winter was a very mild one.

Spring.—The temperature of the spring months was 51°·55, which is rather below the mean for this climate. The amount of rain was quite abundant, especially in April, and is very important, as laying the foundation for the grass crop and other cereal productions.

Summer.—The temperature of the summer months was 72°·43, which is higher than any previous one for many years, the mean average being about 70°, or rather less. The heat commenced in June, and one of the hottest days was the thirtieth, rising to 95°. July is generally the hottest month, but in 1853 the temperature was three and a half degrees below that of June, being only 71°·15, and the latter 74° 60. At Cincinnati the heat was considerably greater than in Marietta, rising on two days to 98°, and on several to 94°. The mean for the month was five degrees above us, or 79°·32. It was six degrees above the mean for June in the last ten years. With this greatly increased range of the thermometer there was a less amount of rain than usual, there being quite a drought in June and July, which was doubtless one cause of the heat. It had a favorable effect

on the grape crop throughout the State, and especially near Cincinnati, where the vine is extensively cultivated. The fruit ripened early and without any tendency to mildew and blight, as it does in wet seasons, especially the last of June. Wheat also felt the healthy influence of dry weather, while maturing its seed; and was never of a better quality or more abundant in quantity. The heat of August was a little above July, owing, probably, to a less amount of rain, being only about half as much.

Autumn.—The mean for the autumnal months was 52°·12; and is higher than the average by one or two degrees, arising chiefly from the heat imparted to the earth in the summer months being radiated in September. The fall was very favorable to the ripening of fruits and grain, Indian Corn never being better, notwithstanding the excessive drought of June. It is a wonderful plant, and when judiciously tilled in a congenial climate, resisting both wet and dry weather above all other grains, its long fibrous roots penetrating the earth to a great depth, while its broad, tapering leaves, collect the dews and fogs from the night air, conducting the moisture to the ground, so that in droughts the soil is wet in the morning at the base of the stalks. For actual nutritive qualities, it stands at the head of all the grains, and will yield the greatest amount of bushels to the acre. Without this plant, the surplus production of beef and pork in the valley of the Ohio, would be small.

Floral Calendar.—March 3d, Yellow Crocus in bloom; 15th, Snow Drop; 22d, Bluebird building her nest; 24th, Hepatica triloba: 29th, Martin appears; 31st, Earth very dry, less than an inch of rain all the month.

April 1st, Primrose in bloom, Crown Imperial stalk sixteen inches high; 2d, Early Hyacinth, Forsythia viridissima, or Golden Bell—a new shrub from China; 7th, Hyacinth in full bloom, Narcissus, several varieties; 8th, Apricot; 9th, Peach in warm exposures, Crown Imperial; 11th, Sanguinaria Canadensis, hard frost this morning, temperature 24°; 12th, Peach generally in bloom, Pear just ready to open; 13th, Spirea Prunifolia; 17th, Sugar Maple; 18th, Cherry tree, Plum tree; 21st, Strawberry; 22d, Pear in full bloom; 25th, Apple tree, Red bud or Judas tree; 27th, Lilac in full bloom, Tulip begins to open.

May 2d, Tree peony in bloom, Chickasa plum; 4th, Quince, Black Haw; 11th, Weigelia rosea, one of the most beautiful and hardy flowering shrubs from China; 13th, yellow and white Calceolaria; 16th, Magnolia triple; 17th, Locust, Acacia robinia; 20th, Early Strawberry ripe, Burr's pine; 21st, White peony; 24th, Purple peony; 29th, Peas fit for table, Prince Albert. June 1st, Syringa fragans; Syringa Philadelphica; 12th, Ribes villosa; 17th, Cucumbers on table grown in open air with slight

protection; 20th, Red Cherry ripe; 22d, Antwerp Raspberry; 25th, Wheat harvest begins, a week earlier than common, from the heat and drought—less than an inch of rain during this month, meadows ready for mowing.

July 6th, Blackberry ripe; 15th, Sweet bough apple; 17th, Chandler Apple.

The crops of grain, potatoes and fruit good; the sweet potato was excellent; melons in great perfection, the hot and dry weather congenial to their habit; grapes were more abundant and perfect than in any former year.

Marietta, Ohio, Jan. 9, 1854.

Art. XXIX.—*On the Eye and the Organ of Hearing in the Blind Fishes (Amblyopsis spelæus, Dekay) of the Mammoth Cave;* by Jeffries Wyman, M.D.

The general structure of the blind fishes was described in a former number of this Journal,* but a more complete description was given in the New York Journal of Medicine, by Telkampf, who in company with J. Muller of Berlin, for the first time detected the existence of rudimentary eyes.† They are described as one twelfth of a line in diameter, round, black, destitute of a cornea, having an external layer of pigment, beneath which is a colorless membrane. No nerve was detected in connection with the eye, and the contents of the globe were not determined with certainty. Prof. Owen has described the organ as a simple eye-speck, "as in the leech, consisting of a minute tegumentary follicle, coated by dark pigment which receives the end of a special cerebral nerve."‡ Dr. John C. Dalton, Jr. has also detected the eyes and describes them as minute globular sacs containing blackish pigment, deeply imbedded in the adipose tissue of the orbit and measuring a little less than one seventy-eighth of an inch.§

Through the kindness of Mr. Charles Dean of Cambridge, and of Prof. Agassiz, I have had placed at my disposal some specimens of Amblyopsis, well preserved in alcohol, and have been able to make in some respects a more complete description than has as yet been given. I have had also an opportunity of inspecting superficially fourteen specimens varying from one inch and a half to four inches and a half in length, but in three or four only

* Vol. xlv, p. 94, July, 1843.

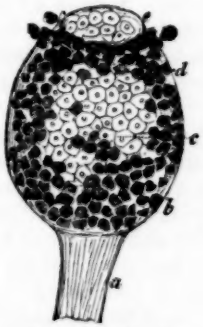
† New York Journal of Medicine, vol. v, p. 84, 1845. Dr. Dekay had previously mentioned the existence of eyes, but was evidently misled by some other appearance, since he states that eyes exist of the usual size, but are covered by the skin. He had not dissected them. Fauna of New York.

‡ Lectures on Comp. Anat., vol. ii, p. 202. See also his figure, p. 175.

§ New York Medical Times, vol. ii, p. 354.

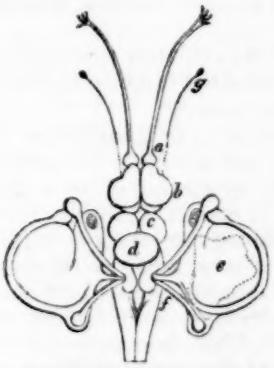
could the eyes be detected through the skin. In the three specimens recently dissected, the eyes were exposed only after the removal of the skin, and the careful separation from them of the loose areolar tissue which fills the orbit. In a fish four inches in length the eyes measured one-sixteenth of an inch in their long diameter, were of an oval form and black. A filament of nerve (fig. 1*a*) was distinctly traced from the globe to the cranial walls, but the condition of the contents of the cranium from the effects of the alcohol, was such as to render it impracticable to ascertain the mode of connection of the optic nerve with the optic lobes. A few muscular fibres were traced to the immediate neighborhood of the eye, and even in contact with it, but were not ascertained to have that regular arrangement which is seen in the more completely formed eyes of other fishes.

1.



Eye of Amblyopsis.

2.



Brain and auditory apparatus.

Examined under the microscope with a power of about twenty diameters, the following parts were satisfactorily made out: 1st, externally an exceedingly thin membrane, *b*, which invested the whole surface of the eye and appeared to be continuous with a thin membrane covering the optic nerve, and which was therefore regarded as a sclerotic; 2d, a layer of pigment cells, *d*, for the most part of a hexagonal form, and which were most abundant about the anterior part of the eye; 3d, beneath the pigment a single layer of colorless cells, *c*, larger than a pigment cell, and each cell having a distinct nucleus; 4th, just in front of the globe, a lenticular shaped, transparent body, *e*, which consisted of an external membrane containing numerous cells with nuclei. This lens-shaped body seemed to be retained in its place by a prolongation forwards of the external membrane of the globe; 5th, the globe was invested by loose areolar tissue, which adhered to it very generally, and in some instances contained yellow fatty matter; in one specimen it formed a round spot visible

through the skin on each side of the head, which had all the appearance of a small eye;—its true nature was determined by the microscope only. It is not improbable that the appearance just referred to may have misled Dr. Dekay—where he states that the eye exists of the usual size, but covered by the skin.

If the superficial membrane above noticed is denominated correctly the *sclerotic*, then the pigment layer may be regarded as the representation of the *choroid*. The form as well as the position of the transparent nucleated cells within the choroid correspond for the most part with the *retina*. All of the parts just enumerated are such as are ordinarily developed from and in connection with the encephalon, and are not in any way dependent upon the skin. But if the lenticular shaped body is the true representative of the crystalline lens, it becomes difficult to account for its presence in Amblyopsis according to the generally recognized mode of its development (since it is usually formed from an involution of the skin) unless we suppose that after the folding in of the skin had taken place in the embryonic condition, the lens retreated from the surface, and all connection with the integument ceased.

According to Quatrefages, however, the eye of Amphioxus is contained wholly in the cavity of the dura mater, and yet it has all the appearance of being provided with a lens. If his description be correct, then the mode of development as well as the morphology of the eye in this remarkable fish is different from that of most other vertebrates, since the lens never could have been formed from an involution of the skin, nor could the eye with its lens, as Prof. Owen asserts, be a modified cutaneous follicle. That there should be different modes of development of parts of the eye in different animals is by no means improbable, since we find this actually to be the case in another organ of sense, the nose. In some fishes the nostrils result from a depression or involution of the skin simply, and do not at any period communicate with the mouth; while in all of the higher vertebrates they are formed by subdivision of the primitive oral cavity. It is possible, therefore, that in Amblyopsis the lens may have been developed where we find it, and that it was never connected with the integument. Whatever views be taken with regard to its development, the anatomical characters which have been enumerated show, that though quite imperfect as we see it in the adult, it is constructed after the type of the eyes of other vertebrates. It certainly is not adapted to the formation of images, since the common integument and the areolar tissue which are interposed between it and the surface would prevent the transmission of light to it except in a diffused condition. No pupil or anything analogous to an iris was detected, unless we regard as representing the latter the increased number of pigment cells at the anterior part of the globe.

The Ear.—It is said that the blind fishes are acutely sensitive to sounds as well as to undulations produced by other causes in the water. In the only instance in which I have dissected the organ of hearing (which I believe has not been before noticed) all its parts were largely developed, as will be seen by reference to figures 2 and 3. As regards the general structure, the parts do not differ materially from those of other fishes except for their proportional dimensions. The semi-circular canals are of great length, and the two which unite to enter the vestibule by a common duct, it will be seen, project upwards and inwards under the vault of the cranium, so as to approach quite near to the corresponding parts of the opposite side. The otolite contained in the utricle was not remarkable, but that of the vestibule (fig. 3) andwhich is seen in dotted outline in fig. 2 *e* is quite large when compared with that of a Leuciscus of about the same dimensions as the blind-fish here described.

3.

Otolite.

The parts represented in fig. 2 are the olfactory lobes and nerves *a*, the cerebral lobes *b*, optic lobes *c*, the cerebellum *d*, the otolite in situ *e*, the medulla oblongata *f*, and the eyes *g*.

The parts in figures 2 and 3 are enlarged three times linear measurement.

ART. XXX.—*Additional Note to Researches on the Development of the Viviparous Aphides;** by W. I. BURNETT, M.D.

SINCE the preparation of the paper on the development of Aphides, which appeared in the last number of the Journal, I have enjoyed the opportunity of making this series of investigations more complete by an examination of the terminal or last brood which appears at the end of autumn.

This terminal brood has hitherto been considered, as far as I am aware, to be composed exclusively of males and females, or, in other words, of perfect insects of both sexes. I was surprised, therefore, on examining the internal organs of the non-winged individuals, to find that many of these last were not females proper, but simply the ordinary gemmiparous form already described. Moreover so great was the similarity of appearance between these two forms—true females and gemmiparous individuals—that they could be distinguished only by an examination of their internal genitalia. Among the proper females there were, besides those which were filled with eggs or had already deposited them, other individuals in which the ovaries were but feebly developed, or at least, in which no mature eggs had been formed. An opportu-

* This volume, page 62.

nity was thereby afforded me to examine the structural differences between the true ovaries and their *quasi* representatives—the bud-like processes. The true ovaries had their usual, well-known structure—multilocular tubes containing nucleated cells which are probably the undeveloped germs; the bud-like processes, on the other hand, consisted of a row of cell-masses, oval and connected by a kind of peduncle, as described in detail in the preceding paper. These wide differences have, more than ever, persuaded me of the morphological dissimilarity of these two kinds of reproducing parts in this animal. It seems to me then that the real intrinsic difference between an ovum and a bud lies as deep as the conditions of sex itself, notwithstanding the latter often has, as in the present case for instance, some of the morphological characteristics of the former.

The appearance of sexless, gemmiparous individuals in the terminal brood would seem to indicate, moreover, that the conditions which determine the appearance of individuals usually exclusively male and female, are not, perhaps, referable to the fact of this being the last brood, but rather to relations of warmth and nutrition. This view is rendered more probable by the fact of the variation in the number of broods between the first and last, observed in the same species on different years—ranging between seven, nine, eleven or more. Moreover, Kyber, as quoted already in the preceding paper, by nursing continually in a warm room a collection of *Aphis dianthi*, keeping about them a summer temperature, succeeded in continuing uninterruptedly the series of sexless or gemmiparous individuals for four years. There are many other facts in insect life that indicate in like manner some direct relation between temperature and nutriment, and definite sexual development. The subject is as important as it is interesting in physiology, and these very animals will, perhaps, subserve the successful study of the primary morphological conditions of sex.

ART. XXXI.—*Correspondence of M. Jerome Nicklès, dated Paris, December* 30, 1853.

Academy of Sciences: Election of a Perpetual Secretary.—The Sciences represented in the Academy are divided into two classes: the *Mathematical* and the *Physical*. Each of these classes is subdivided into sections, consisting of six members, excepting the sections of Geography and Navigation, which have only three. The Mathematical class comprises five sections, as follows: *Geometry*, *Mechanics*, *Astronomy*, *Geography and Navigation*, and finally, *General Physics*. The class of the Physical Sciences contains six sections, namely, *Chemistry*, *Mineralogy*, *Botany*, *Rural Economy*, *Anatomy and Zoology*, and *Medicine and Surgery*. The President of the Academy is

elected for a year, and chosen alternately from the two classes. Each of the classes is represented also by a perpetual secretary, usually elected from its numbers. Thus Arago, of the Astronomical Section, was the Perpetual Secretary for the Mathematical Sciences, and M. Flourens, the distinguished physiologist is perpetual secretary for the class of the Physical Sciences.

Besides the sixty-three members, having a right to vote, there are also ten *free Academicians*, eight Foreign Associates, and 100 corresponding members, of which 45 pertain to the Mathematical class and 55 to the Physical.

The Academy of Sciences is hence organized, so as to include the most distinguished representatives of the sciences of all countries, and nominations are held very select. It is hence understood why the election of a perpetual secretary is an occurrence of great importance, and should have been with the Academy the subject of constant deliberation, ever since the death of Arago. When the decision was to be made, a large number of names were put on the roll; and finally the commission for preparing the list of candidates, fixed upon three names, taken from the Mathematical class, MM. Charles Dupin, Lamé, and Pouillet. On the proposition of M. Cauchy, the Academy added to those names that of the able geologist, Elie de Beaumont. The Academy was nearly complete in its attendance. Members detained at home for a long time past, on account of health, were conveyed to the meeting. Two ballotings took place, and on the second, the name of Elie de Beaumont was drawn out from the urn victorious, to the great disappointment of the Mathematicians, already inferior in numbers, and whose votes were divided between the three candidates.

A fifth name was obstinately put into the urn: it was that of M. de Senarmont, to whom mineralogical physics owes so much of its recent progress. For some time M. de Senarmont was the preferred candidate: but he declined the honor, excusing himself on the ground of his delicate health.

This election took place at the session of the 19th of December. M. Elie de Beaumont is fifty-five years of age. He was born on the 15th of September, 1798. One of his principal scientific claims consists in his labors along with von Buch, for the establishment of the theory of Elevation, which he has developed and extended. He is an elegant writer, and has vast literary acquirements; but it is against him that he has a feeble voice, which will hardly be heard in the Hall of the Academy, amid the agitations of the meetings, where they have been accustomed to the powerful resounding voice of Arago.

Publication of the works of Arago and Laurent.—The works of these two great philosophers are now in the press. The works of Arago will make 12 volumes in 8vo, and will consist of original memoirs, reports, historical eulogies, several of which have not yet been published, and a popular Astronomy. The printing is rapidly going forward.

Circumstances have hindered thus far the entire publication of the work left by Laurent,—a work in which this chemist, so prematurely taken from science, rapidly collected together his views on chemical theories, along with a historical account of organic chemistry, in the

construction of which branch of science he had had so large a part. The work is now in press and will soon be published. The avails of its publication are the only dowry which the unfortunate Laurent left to his widow and children, his long sickness having absorbed all his resources. As an addition to this, the French savants, headed by MM. Biot, Thénard, Dumas, Pelouze and Balard, have set on foot a subscription, to which all friends of science are invited to contribute.

Death of Theodore Olivier.—This representative of Descriptive Geometry, the student of Monge and of Hachette, the Director of the Conservatoire des Arts et Métiers, died recently while at the South for his health. Born at Lyons on the 21st of January, 1793, he early entered the Polytechnic School, where he became distinguished for his mathematical tastes, and especially for Descriptive Geometry, to which he afterwards devoted his life. He became Lieutenant of the Artillery and was attached as Professor to the School of Applied Science at Metz. In 1821 he was invited to Stockholm by the Swedish government, and established there a Polytechnic institution. On returning to France he organized, in conjunction with MM. Dumas, Péclet, and Lavallé, the Central School of Arts and Manufactures, which has produced all the distinguished engineers of the country, and which is now attended by students from all parts of Europe.

Olivier was an able Professor. His language, clear, precise and elegant, fitted him for public instruction. A chair of Descriptive Geometry was created for him at the Conservatoire des Arts et Métiers, and he filled it with distinction till the time of his death. For illustration in his lectures, he constructed moveable silk-thread models, such that the surface represented by the model could be changed from a surface of one kind to that of another. This unique collection consists of over 50 models, made with most admirable care, precision and economy. Besides this collection, there is another likewise made by Olivier, illustrating the movements of cog-wheels, either as employed in the Industrial Arts, or as interesting simply in a mathematical point of view in the transmission of motion.

In 1815 he published an important memoir on White's theory of cog-wheels without friction from sliding. He afterwards occupied himself with the study of nodes. In 1842, he published his geometrical theory of cog-wheels; in 1843, his "Developpements de Géométrie Descriptive;" in 1845, a continuation on this subject; in 1847, its applications; in 1852, the 1st part of a new edition of his Memoirs, the continuation of which was occupying him intently when he was taken from Science, his pupils, and his friends.

M. Olivier succeeded General Morin in the direction of the Conservatoire des Arts et Métiers, and his place has been filled by M. Morin, celebrated for his fine work on Mechanics.

On the Proximate principles of Bran of Wheat.—Some years since, M. Millon, as a result of long labor, arrived at the conclusion that *bran is an alimentary substance;* that bran bread, and pilot bread ("pain de munition") was more healthy and more nutritious than white bread. This opinion has been contested, and Millon has been ironically attacked for not conforming to the regimen he recommends. But the opinion is now sustained by Chevreul, who declared his views on the

occasion of a memoir of M. Mourier on this subject. It is known too that according to Magendie's experiment, dogs could live on bran bread, whilst they died when kept on white bread. This fact which appeared so singular, is explained through the researches in question.

The inner surface of bran is covered with azotized principles which like diastase will dissolve starch, changing it into dextrine and sugar. These principles differ somewhat from diastase; still it is demonstrated that the bran acts as a ferment in fermentation, and consequently in a similar manner in digestion.

On the Ammonia contained in Rain-water.—M. Boussingault has continued at his country seat at Liebfrauenberg (Lower Rhine) his researches mentioned in the November number of this Journal. From his new investigations it appears that the rain of the country contains less ammonia than that of the city, and that the ammonia is more abundant at the beginning than at the end of a shower.

Boussingault has examined also the dew, and always found it to contain ammonia. The proportions, by several trials, were 6 milligrams to the litre; but the amount is reduced to 1·02 after a rainy day. On the 14th to the 16th of November a thick mist prevailed, so rich in ammonia, that the water had an alkaline reaction; a litre of the water contained about 2 decigrams of carbonate of ammonia. Seventy-five rains (including the dew and mist) examined by Boussingault between the 26th of May and the 8th of November, contained, as a mean, half a milligram of ammonia. The great quantity of ammonia contained in the mist appears interesting in its bearing on vegetable pathology: in fact, although ammonia in small quantity is favorable to vegetation, a large proportion would be injurious, and would show its effects especially on the leaves of flowers. Moreover, such a storm might have a deleterious influence on respiration, and especially on the lungs of persons with pulmonary affections.

Heating of Wire by the Voltaic Current.—Suppose we have a platinum wire, a, b, inserted between the electrodes of a battery composed of n elements; and we apply to two points, α, β, in the platinum wire, the electrodes of another battery also composed of n elements, two cases will be presented, according to the direction given to the currents; if the currents are contrary in direction, the intermediate space $\alpha\ \beta$ of the wire, will be instantly cooled so that you may touch it with your finger without burning it; whilst the two extremities $\alpha\ b$ and $a\ \beta$ will be raised to a temperature much higher than before. On reversing the direction of the current of the pile B, it will be, on the contrary, the portion $\alpha\ \beta$ of the wire which becomes highly heated, whilst the outer parts are reduced to a low temperature.

These facts, in which MM. de la Provostaye and Desains seem to see arguments against theory, are not out of the domain of acquired facts. These physicists admit that both currents traverse the joining wire, that they neutralize one another in one case, and add to one another in the other; and as the development of heat is regarded as due to the reunion of the two fluids, nothing prevents that the four equal streams should combine two and two in the common part of the current, and produce in all cases an elevation of temperature alike whatever may be the direction of one of the currents.

But this is not so in the experiment, and because the currents do not pass along the wires as MM. de la Provostaye and Desains regard it. By the aid of the platinum wire the two circuits of the pile form no more than one, whose tension varies with the direction of the currents. When both are propagated in the same direction, $a\,\alpha$, $b\,\beta$, the battery is arranged for quantity, and the wire reddens throughout its length. On the contrary, when the currents pass in opposite directions, the batteries A and B are coupled for tension, a condition less favorable for heating the wire. Such is the impression which has been produced in general by the reading of the note of MM. de la Provostaye and Desains. The explanation which we have just given appears to accord perfectly with the facts. I may be permitted to mention here an experiment made by me some years since, which constitutes a peculiar form of these phenomena.

I take an electromagnet which I place in a circuit, formed of four of Bunsen's pairs. The electromagnet carries 200 kilograms. If now I interpose four other elements *in an opposite direction*, I ought to have 0, according to both theories; in fact the magnetization disappears entirely. But if in place of four reversed elements I take only *two*, I find that the electromagnet retains part of its force; and, provided the mode of communication of the conductors remains the same in both cases, the batteries alone are varied. In this experiment, the currents were of contrary sign, as in the experiment $a\,b$, $a\,\beta$, cited above, and by the mode of communication the pile was arranged for tension. The partial magnetisation produced in this case proceeds necessarily from a *derived* current; in the experiment with two batteries of four elements each, of contrary sign, the currents were equal in intensity, and opposite, and the power of the magnet $= 0$. In the other experiment, the difference in the two batteries caused a corresponding difference in the derived currents, and the magnet was in a certain degree magnetised.

Various Memoirs.—Among the memoirs brought before the Academy during the last three months, there are the following. One by Dr. Brainerd, of Chicago on the *means of neutralizing the poison of rattlesnakes;* presented through M. Flourens.—An interesting memoir by M. Langlois, Chief Physician at the Hospital "des Invalides," *on the action of carbonic acid on quinine and cinchonine;* M. Langlois finds that quinine left in water is rapidly dissolved under the influence of a current of carbonic acid and then crystallizes as carbonate.—Two memoirs by M. Virchow, relating to *the discovery in the human body of a substance of animal origin offering all the characters of cellulose;* the seat of this substance is in the brain and spinal marrow.—A Report by M. Pelouze on a work of some extent by MM. Rivot, Boguin and Beudant, made at the School of Mines, *on the use of chlorine in analysis.* Several new processes are brought forward: the problem is solved of the complete separation of lead and sulphur, and the analysis as exact as rapid is made of galena, by the aid of chlorine and an alkaline solution. All mineral substances are brought under consideration by the authors. They even employ their process in some cases of organic analysis, using it for example, for testing the sulphur of vulcanised india-rubber, etc.—A memoir of M. Schlösing, on testing for nitric acid accompanied by organic matters. The author who is inspector of tobacco, has applied his process to this vegetable substance.

We should also mention a fine work of M. Melloni on the magnetism of rocks, which tends to modify a little our mode of viewing magnetic polarity of many substances. But besides the abstract in the Comptes Rendus of the Academy, the paper has appeared entire in *L'Ateneo Italiano*, which is published at Paris, and whose principal end is to popularize and diffuse science in Italy.

Chemical reactions effected under the influence of High Pressure.—Towards the close of the last century, Hall fused carbonate of lime without decomposition, by means of a high temperature (21° to 23° Wedgewood). The means he used were suggested by considerations published by Hutton, respecting the influence that pressure might exert on geological phenomena. Hall used a closed vessel under a pressure of 8 atmospheres. In 1844, M. Fournet of Lyons called attention to this method, and since that time, these chemists have made frequent use of it. So also, M. Cagnard Latour, has operated on wood, converting it into a bituminous matter,—M. de Senarmont applies it to the artificial reproduction of minerals,—M. Schrötter, to changing ordinary phosphorus to red phosphorus,—M. Frankland, in his researches on the radicals, ethyle, methyle, amyle, etc.

Finally, M. Berthelot, by operating under pressure with heat, succeeds in preparing the fatty bodies by means of glycerine and the corresponding acid. We have already spoken of his labors.* He has recently made a full report of his results to the Academy, and we mention some of them. Numerous precautions are necessary in operating thus on organic matters, to avoid explosions and the burning that may follow them. The following details are from the *Journal de Pharmacie et de Chimie.*

Heating Apparatus.—We here speak only of processes carried on with a temperature above the boiling point of water, and in which an oil bath is used: oil prepared by long ebullition will support without boiling, a temperature near 400° C., and is decomposed only at a red heat.

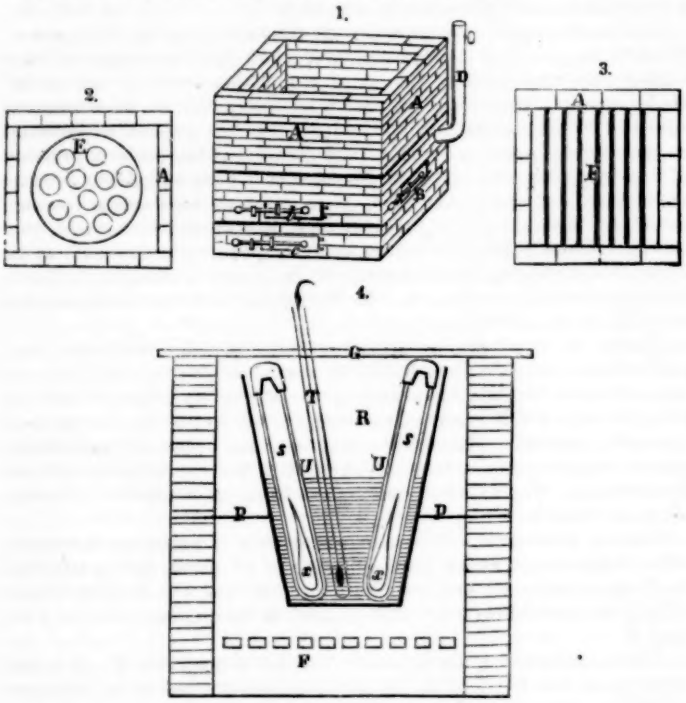
To avoid accidents, the following are his arrangements. A square structure or vat, A, of brick, divided into three unequal parts, one above the other, contains the furnace, *b*, B being the doors, *c* the ash-pit, D the chimney; a plate of iron separates this part from the oven of the upper part. This plate has a circular hole, for receiving the boiler R, which contains the oil. This boiler is conical, at least 75 centimeters in height, so that its aperture is but little below the upper level of the vat. To prevent risk to the operator, it is necessary to close the opening of the vat with a heavy plate of iron. The space containing the oil bath is thus closed on all sides.

The boiler is half filled with oil; and the temperature of the oil is shown by a thermometer, T, placed in a metallic tube which passes through a hole in the upper plate.

The closed vessels which are heated in this oil bath are almost always tubes of glass; and in order to avoid accidents from their explosion, they are enclosed in iron tubes (*s*), solid at one end, and at the other closed by a screw head. In spite of the precautions there are

* This Journal, vol. xvi, p. 100.

occasional explosions, which throw out or set fire to the oil, in consequence of the projection through the oil of gases produced by the explosion. M. Berthelot avoids this result by surrounding the iron tube by a case ("manchon") of sheet iron, closed below: the gas in this case, does not pass into the oil, but escapes above.



Explanation of the Figures.—1. A, brick structure, reduced to one-twentieth; *b* B, doors of the furnace; *c*, ash-pit; D, chimney.—2. Horizontal section of the structure at the height of the boiler, reduced to one-fortieth; E, boiler with its tubes.—3. Horizontal section of the same at the height of the furnace, reduced to one-fortieth; F, grating.—4. Vertical section, reduced to one-twentieth; R, boiler; *s*, iron tube with screw head; U, sheet iron case enveloping tube; *x*, glass tube contained within the iron tube; T, thermometer enclosed in an iron tube; F, grating; G, cast iron plate; P, sheet iron plate.

In recapitulation, the glass tube (x) is placed in a tube of iron (s), surrounded by a sheet iron case; the whole is heated in the oil bath, enclosed within a brick oven or vat.

The closed vessels employed are either balls, matrasses, or tubes, of glass. The first hardly resist a pressure of more than 3 or 4 atmospheres. They are closed by means of a lamp after the substance is introduced. Glass tubes are generally used; they should be hard, little fusible, unattacked by the reagents and by the heat of a lamp. The glass tubes used for organic analysis, are excellent for the purpose: They will sustain a pressure of 50 to 60 atmospheres; they resist

the tension of water, to about 270° C., and that of turpentine to above 360° C.

Preparation of the tubes.—The tubes are closed at one end with a blowpipe, and reheated in the lamp. After cooling, the solid reagents are introduced, and the open end is drawn to a point: the principal precaution requisite is to see that the tube retains the original relation between its thickness and diameter, upon keeping which, rather than upon its absolute thickness, its power of resistance depends. The tube being cooled, the liquids are introduced, and it is then closed by a lamp leaving a fine point at the extremity,—an indispensable precaution if there is an escape of gas, as the tube may then be opened readily without explosion. The quantity of liquid put in the tubes varies with the heat to which they are to be subjected. If to 360° or 400°, the tubes should not be over one-half or one-third full; and they should be short enough to be entirely covered by the oil when placed vertically in it; if to a red heat, tubes of 50 to 60 centimetres are employed, and they are filled only to $\frac{1}{100}$th or $\frac{1}{50}$th of their capacity.

Opening the tubes.—After the heat has been sufficiently continued, the tube is removed and opened, and this is the time of greatest danger. Often the tension of gas is so great, that the tubes break with the slightest shock. The following precautions are adopted.

1. If the presence of a permanent gas is suspected, it is necessary before heating the tube of glass to surround it with a triple or quadruple fold of wire gauze, extending it and doubling it over both extremities of the tube; only the point of the tube should be out. 2. After the complete cooling of the bath, the iron tube is unscrewed, and the glass tube is slid gently out and received on a linen rag. If the study of the gases developed is not an object in view, the tube is enveloped in 3 or 4 folds of linen, so as to show only the point, and then this point is broken with pliers. In some cases the gases are so abundant that explosion is unavoidable; and if the collection only of the solid ingredients is desired, the tube may be wrapped in linen and thrown on the ground: the solid substances are found mixed with the fragments of glass. If the collection of the gases is desired, other precautions are required which may easily be foreseen.

Economical Manufacture of Bi-chromate of Potash.—M. Jacquelain, Manufacturing Chemist at the Central School of Arts and Manufactures, communicates to the Société d'Encouragement, his researches on the best method of manufacturing bi-chromate of potash. The author has worked for 6 years on this point, and has published at different times papers on the subject. We give here his process, which has been patented.

The ore is (1.) heated to a red heat, and then dashed with cold water; and this is repeated a second time:—(2), then broken under iron rollers or a mill ("moulin à noix"), and afterwards with water under siliceous millstones or of iron, bringing together the millstones, so as to obtain No. 90:—(3), then made into a paste with carbonate of potash, 44 p. c., in an oven of iron, incorporating chalk 90 p. c., and calcining the mixture and drying it completely at 100° C.:—(4), thus calcined, it is put into earthen retorts, which have at the lower part a head of metal provided with an opening for admitting air previously heated, for

the purpose of oxydizing the chrome ore; the upper end of the retort is made to communicate with a chimney furnished with a register in order to regulate the escape of the hot air deprived of oxygen, and directing it upon the liquid of an evaporating boiler, for hastening the evaporation of water:—(5), after the roasting is thus completed, the material is removed to the boilers, to undergo five treatments successively with boiling water, in order to extract all the chromate of potash, using the last waters with a new supply of the roasted ore; if there is some chromate of lime in the liquid it is precipitated by means of carbonate of potash:—(6), the solution of chromate of potash is concentrated to one-third of its original volume, one-half of the potash of the chromate is saturated with sulphuric acid, which allows of a separation at once of the bi-chromate from the insoluble sulphate of potash which is precipitated; then the concentration is completed before conducting the liquid to the vats for crystallization.

M. Jacquelain expects considerable profit from this process, obtaining 425 francs for 500 kilograms of the bi-chromate, which amount may be manufactured in one day. To 100 kilograms of ore, 45 p. c. in purity, there is added successively 90 kilograms of chalk, 44 of carbonate of potash, and sulphuric acid to the value of 6½ francs; and from this 78 kilograms of the bi-chromate are obtained.

Photography.—For some time past, naturalists have sought to apply photography to zoological studies. A very successful attempt has been made by MM. Rousseau, naturalist attached to the Museum, M. Deveria, artist connected with the National Library, and Bisson Brothers, photographers. They have taken numerous photographs of animals with great success. We have seen figures of a Fungia, smaller than nature, which under a lens showed every tooth and plate of this coral with perfect distinctness. This fidelity could not be attained by the hand of man. As photography thus gives us economically what could not be obtained otherwise for any price, the Academy of Sciences, on the Report of M. Milne Edwards, have become impressed with the importance of these attempts, and have supplied MM. Rousseau and Deveria with the materials for prosecuting their labors in good earnest.

Another photographer, M. Bertsch, has presented to the Société d'Encouragement some fine photographic pictures taken under a microscope, and very much enlarged, of a tissue made up of a mixture of wool, cotton, and flax-cotton, and it is remarked that the fibres of these different substances show well their distinctive characters.

On learning the death of Arago, a French photographer, M. Claudet, established for some years in London, recalled his having taken in 1843, some Daguerreotypes of this philosopher. M. Claudet, aided by M. Lerebours, has taken from different positions pictures from the Daguerreotype, such as may be used with a stereoscope; and we now have a stereoscopic picture of the man who may be said to have acted as godfather to the Daguerreotype.

M. Niepce de St. Victor, of whom we have spoken in the number for November last, proposes to extend the use of his new process on glass, and operate with it as for an engraving on steel. When the plate has received an impression, he submits it to the vapors of fluohydric acid or else pours upon a little of the liquid acid; in the first case, the engraving is unpolished, in the second, it is deep and transparent.

Chemical examination of four new Quinquinas from the Province of Ocagna, New Grenada.—These four Quinquinas have never appeared in commerce, and it was important to ascertain their richness in quinine and cinchonine. M. Bouchardat, Chief Professor of the Faculty of Medicine and Pharmacy of the Hotel Dieu, who is preparing a monograph upon the Quinquinas both in a commercial and therapeutic view, is especially occupied with this question. The analyses of these Quinquinas were made by M. Ossian Henry, Jr. The results are given below:

No. 1. Specimen labelled Pale Red Quinquina from New Grenada.
No. 2. " " White " from the province of Ocagna.
No. 3. " " Brownish red " " "
No. 4. " " Rose red " " "

One kilogram of the Quinquina afforded, in grammes:

	No. 1.	No. 2.	No. 3.	No. 4.
Sulphate of Quinine,	0·18	0·06	——	15·50
Cinchonine, . .	0·02	0·12	——	4·00

It is seen that only one of these Quinquinas is of any interest: it is No. 4. M. O. Henry has not been able to determine the species to which the bark belongs.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Bartlett's Elements of Analytical Mechanics.*—Prof. Bartlett has presented the American student with a very complete and excellent introduction to the science of mechanics. A work in which the analytical or deductive method of investigation is systematically carried out, and is at the same time set forth in such a manner as to be intelligible to those who possess a fair knowledge of the calculus, has long been needed. We believe that Prof. Bartlett's work is the only treatise in our language in which this has been attempted. English writers on mechanics, following Poisson, begin their treatises by more or less simple demonstrations of the parallelogram of forces, and from this proposition ascend gradually to higher developments and to more general formulas. This method has undoubtedly its advantages and furnishes to a large class of minds the best introduction to a knowledge of the science. On the other hand the student who wishes to attain a complete command of general methods of investigation must pursue at one period or another in his studies a different course, and must gain that faculty of deducing particular results from general formulas which constitutes analysis. The whole science of mechanics is contained in six equations. Prof. Bartlett, following Lagrange, deduces these equations after a brief preliminary introduction giving the necessary definitions and explanations of the terms used. From these equations formulas applicable to particular cases are deduced, and the work will be found very thoroughly and completely illustrated by examples and problems. Much matter of a purely practical character is introduced, and the

treatise terminates with a series of tables of coefficients of friction, resistances to compression, tenacities, densities, &c. On the whole the work, though not free from faults, will give a real impulse to the cause of sound scientific education, and will be welcomed by both students and teachers. Mechanics is the mother of the physical sciences, and its study must precede that of any branch of physics. Any work which throws light upon its difficulties or which renders its study more attractive must be gratefully received, and regarded as a contribution to every branch of physical science. Prof. Bartlett's work promises to do good service as a carefully considered and well digested treatise upon one of the most difficult but most beautiful and useful of the sciences.

2. *Darstellung der Farbenlehre und Optische Studien von* H. W. Dové.—Under this title Prof. Dové has published the second edition of an admirably clear and well written exposition of the theory of colors. The first edition of this work appeared in 1836, and has long been out of print. The author has now materially enlarged and in some measure recast it, and has added a series of original investigations upon various optical subjects of great value and interest. The work has the rare merit of being both popular and scientific. It is perfectly intelligible to any cultivated mind, while to the physicist by profession, and especially to the teacher of physics, it is full of suggestions which serve to illustrate and adorn familiar topics. The work commences with a historical introduction concerning the propagation of light and the earlier views of its nature. From this it passes to a brief consideration of the Newtonian theory and its final and complete overthrow, and then, after allusion to the now almost forgotten vagaries of Goethe, proceeds to the main portion of the subject. The author classifies colors according to their origin, into Prismatic Colors or colors produced by refraction, Colors of Interference, and Colors of Absorption. These three classes of colors differing in origin are then separately considered, and the application of the wave theory to their explanation pointed out. The papers collected under the name of Optical Studies relate to stereoscopic experiments and apparatus, to the polarization of light, and to experiments on subjective colors. The style of the work is lively and attractive, and we are glad to learn that an English translation of it may be expected.

3. *Einleitung in die Höhere Optik von Dr.* August Beer.—With this title Dr. Beer has published a treatise upon the wave theory of light, which is in all respects the most complete and satisfactory general view of that theory which has yet appeared. It is true that almost all the best recent treatises on physics employ the doctrine of undulations exclusively. General treatises on physics, however, are rarely sufficiently full and explicit in the details of the application of theories, and usually confine themselves in a great measure at least to phenomena. The great work of Herschel on light has long been behind the age, while Radicke's Handbuch der Optik is obscure and not suited to the wants of the learner. Meantime memoirs and investigations without number have appeared, and the theory of waves may now be justly considered as almost perfect, and as entitled to rank with the theory of gravitation—in short to be considered as the second great physical generalization to which the human mind has arrived. A complete and

thorough elementary work on this branch of science has long been needed, and Dr. Beer's treatise deserves all praise. The work is divided into two parts. The first division, which is of a more elementary nature, treats of the principles of the wave theory for the simple case of isotropic media. The explanation of the attributes of color, intensity and polarization, is clearly set forth, and the fundamental laws of Catoptrics and Dioptrics are theoretically deduced. This portion of the work is in itself a very full treatise on descriptive Photics, though in a few particulars, as for example, upon the subject of circular polarization, more details would have been desirable. The chapter on interference is particularly worthy of notice, the subject being treated in the most general manner. This portion of the work closes with a description of Fessel's wave machine, for the representation of plane circular and elliptically polarized waves, as well as for the illustration of the interference of two rays. The second division treats of the analytical deduction of the laws of the motion of light, and of their experimental confirmation. The author obtains the equations for the condition of rest in the particles of the ether, and then those for a motion consisting of very small oscillations. The second chapter treats of isotropic media; the third of anisotropic media in general, and from this to the eleventh chapter inclusive the work is devoted to the phenomena of the motion of light in crystalline media. The treatise concludes with a description of the beautiful model of the wave surface in a biaxial crystal executed for Prof. Magnus, and the same we believe which was exhibited at the World's Fair in London, in 1852. In the body of the work many tables of optical constants are introduced, while the appendix gives the indices of refraction for a great number of substances as determined by different observers. This last table, however, as the indices do not refer either to definite rays in the spectrum, or to substances of definite constitution, is rather a blemish upon the work. Upon the whole, then, we regard Dr. Beer's treatise as one of the most truly important and valuable contributions to scientific literature which have appeared in recent times, and it is to be hoped that it may soon appear in an English dress, and thus become more generally accessible and useful.

4. *Die Lehre von der Reibungselektricität von* P. T. Riess.—Prof. Riess is one of the few physicists who has devoted his energies exclusively to the subject of frictional electricity—a subject which, though at one time very popular, has of late years been but little studied. The treatise before us is of a truly German character. It embraces the whole subject of which it treats, and it exhausts that subject completely and systematically. The author divides his work into six sections. The first treats of the action of electrified bodies during their insulation. The second of the action of electrified bodies during their discharge. The third of the mechanism and effect of electric discharges. The fourth of the action of the connecting wire of a battery at a distance. The fifth of the excitement of electricity, and the sixth of atmospheric electricity. The author abstains entirely from theoretical considerations, and devotes his work exclusively to phenomena and their laws. The great mass of isolated experiments with which works on electricity usually abound serves only to confuse the subject, and Prof. Riess

has most judiciously confined himself as much as possible to general principles and to the statement of numerical results. English treatises on physics of late have done little else than re-echo the opinions of the illustrious Faraday upon this branch of science, and we owe this German physicist no inconsiderable debt of gratitude for his faithful exposition and dispassionate criticism of the labors of other experimenters. The results of Prof. Riess's own labors form no inconsiderable or unimportant part of his work, and we find here reproduced his papers on the torsion electrometer, on the development of heat in the connecting wire of the electric battery, on induced electrical currents, and upon many other interesting subjects. No treatise which has yet been published upon frictional electricity, at all compares with this in real extent, fullness and completeness, and it is no small part of its merit that it has been drawn wholly from the original sources, and has not been built up upon some other and older work as a foundation. Such works as this are needed in every branch of science; they demand for their production the clearest insight, the most dispassionate judgment, and the most thorough and comprehensive knowledge. We earnestly hope that Prof. Riess' noble treatise may not long stand alone. W. G.

5. *On the Absolute Zero of the Perfect Gas Thermometer; being a Note to a Paper on the Mechanical Action of Heat;* by W. J. MACQUORN RANKINE, Esq., (Abstract of a paper read to the Royal Society of Edinburgh, 4th January, 1853.)—Temperature being measured by the pressure of a perfect gas at constant density, the absolute zero of temperature is that point on the thermometric scale at which, if it were possible to maintain a perfect gas at so low a temperature, the pressure would be null.

As no gas is entirely devoid of cohesion, the immediate results of experiment give only approximations to the position of this absolute zero. These approximate positions approach nearer to the true position as the gas is rarified.

The author having deduced the true position of the absolute zero from M. Regnault's experiments on atmospheric air and carbonic acid, soon after their publication, announced the result in the Edinburgh New Philosophical Journal for July, 1849, and in the Transactions of the Royal Society of Edinburgh, vol. xx.

The present paper gives the details of the method of determination which he adopted, and a copy of the diagram which he used.

The following were the results arrived at:

The absolute zero of the perfect gas thermometer is

274°·6 Centigrade, or } below the temperature of melting ice.
494°·28 Fahrenheit, }

The coefficient of expansion of a perfect gas, in fractions of its volume at the temperature of melting ice, is consequently,—

Per degree of the Centigrade scale, $\frac{1}{274{\cdot}6} = 0{\cdot}00364166.$

Per degree of Fahrenheit's scale, $\frac{1}{494{\cdot}28} = 0{\cdot}00202314.$

6. *Aridium;* by CAMPBELL MORFIT and JAMES C. BOOTH, (Communicated for this Journal.)—Bahr (*Jour. Prakt. Chem.*, lx, 27,) having

stated his conviction, after recent and careful examination of the Norwegian Chromic Iron Ore, that Aridium, which Ullgren first announced as a new metal obtained by him from that mineral, is nothing more than oxyd of iron admixed with traces of phosphoric acid and oxyd of chrome; we take this opportunity of publishing that our experience is also adverse to the reality of its existence as a distinct element. Of numerous specimens of iron from various sources subjected to a searching method of analysis, (*Chem. Gaz.*, 1853, p. 413.) not one was found to contain a particle of Aridium.

7. *Note to J. D. Dana's Contributions to Chemical Mineralogy*, p. 210; by the Author.—In writing the formulas on pages 218 to 220, fractions are used as preferable often to whole numbers. Thus, $\dot{\mathrm{A}}\mathrm{l}\,\bar{\mathrm{S}}\mathrm{i}^{\frac{4}{3}}$, $\dot{\mathrm{A}}\mathrm{l}\,\bar{\mathrm{S}}\mathrm{i}^{\frac{3}{2}}$, $\dot{\mathrm{A}}\mathrm{l}\,\bar{\mathrm{S}}\mathrm{i}^{\frac{1}{2}}$, $\dot{\mathrm{A}}\mathrm{l}\,\bar{\mathrm{S}}\mathrm{i}$, are obviously more immediately appreciated and compared than the corresponding formulas, $\dot{\mathrm{A}}\mathrm{l}^4\,\bar{\mathrm{S}}\mathrm{i}^3$, $\dot{\mathrm{A}}\mathrm{l}^3\,\bar{\mathrm{S}}\mathrm{i}^2$, $\dot{\mathrm{A}}\mathrm{l}^2\,\bar{\mathrm{S}}\mathrm{i}$, $\dot{\mathrm{A}}\mathrm{l}\,\bar{\mathrm{S}}\mathrm{i}$. The old objection to fractions that atoms are indivisible is of no value. The ratios are correctly presented and these are all that analysis affords. The actual number of molecules may be for the first, for example, $\dot{\mathrm{A}}\mathrm{l}^{40}\,\bar{\mathrm{S}}\mathrm{i}^{30}$ or $\dot{\mathrm{A}}\mathrm{l}^{24}\,\bar{\mathrm{S}}\mathrm{i}^{18}$, etc., and Mr. T. S. Hunt has given good reason for believing that the molecules are in some such multiples. Hence $\dot{\mathrm{A}}\mathrm{l}^4\,\bar{\mathrm{S}}\mathrm{i}^3$, taken as an expression of the absolute number of molecules is beyond doubt false; taken as a ratio simply, the fact is better exhibited by the fraction.

In the formulas, such as $(\frac{1}{2}\dot{\mathrm{R}}^3+\frac{1}{2}\ddot{\mathrm{R}})\,\bar{\mathrm{S}}\mathrm{i}$ or $(\frac{3}{5}\dot{\mathrm{R}}^3+\frac{2}{5}\ddot{\mathrm{R}})\,\bar{\mathrm{S}}\mathrm{i}$, the sum of the fractions is a unit; and in the first of these two formulas, they show that $\dot{\mathrm{R}}^3$ is to $\ddot{\mathrm{R}}$ as 1 : 1; in the second, as 3 : 2. These expressions or formulas of course come under the more general formula $(\dot{\mathrm{R}}^3, \ddot{\mathrm{R}})\,\bar{\mathrm{S}}\mathrm{i}$, in which $\dot{\mathrm{R}}^3$ and $\ddot{\mathrm{R}}$ are represented as mutually replaceable.

In the oxygen ratio of nepheline, on p. 220, 1 : 3 : 4, should be 1 : 3 : 4½.

It may be objected to the new view of the fundamental form of Tourmaline that the planes of it are less common on crystals than those of $-\frac{1}{2}\mathrm{R}$ (the R of authors). But it is true also in Calcite that $-\frac{1}{2}\mathrm{R}$ is one of the most common forms, much more common than R.

8. *On the Production of Crystalline Structure in Crystallized Powders, by Compression and Traction*; by Sir David Brewster, K.H., D.C.L., F.R.S., etc., (Trans. of the Roy. Soc. of Edinb., vol. xx, part 4; cited from the L., E. and D. Phil. Mag., vi, 260.)—The influence of compression and dilatation in producing the doubly refracting structure in solids of all kinds, whether crystallized or uncrystallized, which do not possess it, and in modifying that structure in all crystals which do possess it, has been long known; but with this class of phenomena, those which I am about to describe have no connexion whatever.

In the course of experiments on the *double reflexion* and polarization of light which I discovered in the *chrysammates of potash* and *magnesia*, *murexide*, and other crystals, I was surprised to find that these substances could be spread out upon glass by hard pressure, like grease or soft wax; and that in the case of chrysammate of potash and other bodies, when the powder could scarcely be distinguished from snuff, I obtained a transparent film, exhibiting the phenomena of double reflexion and polarization from its surface as perfectly as if I had been using a large crystal.

In subsequently repeating these experiments, and examining under polarized light the film thus produced by compression and traction, I was surprised to observe that the streaks and separate lines of the film, as well as the film itself, had regular axes of double refraction, as if they were regularly crystallized portions of the substance under examination. These streaks and capillary lines, which were often of extreme minuteness, did not appear to consist of insulated particles merely dragged into a line; but when the substance possessed the new property in perfection, the lines of polarized light were continuous, and the crystallographic as well as the optical axes of the particles were placed in that line. In other cases, where the experiment was less successful, the insulation of the particles was easily recognised, though the general mass of them was crystallographically arranged.

In making these experiments, the natural crystalline powder, or the particles of the crushed crystal, may be placed either upon a polished glass surface or upon a piece of glass ground on one side. In those cases where the substance is soft, the polished surface is preferable; but when the powder is hard, and considerable pressure necessary, it is better to place it upon the ground surface of a piece of glass, as the particles are detained between its minute elevations, and submit more readily to the combined force of pressure and traction. When the powder is thus placed, I take a polished and elastic knife, and with its broad point I compress and drag the powder in a given direction till there is the appearance of a polished surface on the compressed substance. In general, I have used both the smooth and the rough glass, and have frequently obtained results with the one which were not given by the other.

If we now place the plate of glass in a polarizing microscope with the field dark, we shall find that the streaks and lines produced by traction have, in certain substances, regular neutral and depolarizing axes, as if they were prismatic crystals of the substance under examination. With the *chrysammate of magnesia*, a red powder with specks of yellow reflected light, the phenomena are peculiarly splendid; the natural colors of the substance, which vary greatly with the thickness of the streaks and films, being combined with the different tints which they polarize. As the crystals of this substance possess unusual reflexion, this property is displayed in the crystallized streaks produced by traction; and the superficial colors which they reflect vary with the azimuth which the plane of incidence forms with the plane passing through the axis of the prism.

The remarkable property which I have now described I have found, in a greater or a less degree, in the following crystals:—

Chrysammate of magnesia.	Palmic acid.
" of potash.	Amygdaline.
Hydro-chrysammid.	Tannin, pure.
Murexide.	Quinine, pure.
Aloetinate of potash.	" acetate of.
Aloetinic acid.	" sulphate of.
Oxamide.	" muriate of.
Palmine.	" phosphate of.

Quinine, citrate of.
Cacao butter.
Veratric acid.
Esculine.
Theine.
Silver, cyanid of.
" acetate of.
Platina and magnesia, cyanuret of.
" and barytes, cyanuret of.
" potassium, cyanuret of.
" ammonia, chlorid of.
Potash, oxymuriate of.
" chromate of.
Urea, nitrate of.
Sulphur.
Camphor.
Cinchonine.
" sulphate of.
Meconic acid.
Brucine, sulphate of.
Morphia, acetate of.
Tin, iodid of.
Cerium, oxyd of.
Parmeline,
Lecanorine.
Indigo red.
Ammonia, oxalate of.
" sulphate of.
Soda, chromate of.
Lead, iodid of.
Strychnine, sulphate of.
" acetate of.
Soda, native nitrate of.
Berberine.
Mucic acid.
Solanine.
Asparagine.
Mercury, oxymuriate of.
Isatine.
Alizarine.
Manganese, sesquioxyd of.
Lead, protoxyd of.
Tungstic acid.
Chromo-oxalate of potash.

In submitting other crystals to the influence of compression and traction, I have found great numbers which do not exhibit the least trace of transparent streaks and lines, the separate particles being merely dragged into lines, and exhibiting only a quaquaversus polarization. On the other hand, there is another class of crystals whose powders or particles are forced into distinct and transparent streaks and lines, in which the individual particles have a quaquaversus polarization and no trace of a prismatic arrangement. As these crystals have a peculiar relation to those in the preceding list, I shall enumerate the most important of them in the following table; that is, those in which the powder has been dragged into transparent and continnous streaks and lines, resembling externally portions of a solid body; for it is only by a comparison of the physical, or perhaps the chemical qualities of the two classes of bodies, that we can expect to explain the new property which is possessed only by one of them.

Hydrate of potash, pure.
Indigotic acid.
Urea.
Citric acid.
Silver, nitrate of.
Meconine.
Naphthaline.
Soda, nitrate of.
Potash and copper, sulphate of.
Soda, phosphate of.
Soda, acetate of.
Mercury, prussiate of.
" muriate of.
" sulphuret of.
Barytes, acetate of.
Zinc, chromate of.
" sulphate of.
Cobalt, sulphate of.
Magnesia and soda, sulphate of.
Borax.

As both compression and traction are necessary in producing the transparent streaks and lines in both classes of the substances I have

enumerated, it became interesting to ascertain what effect was produced by each of these forces acting separately, and which of them was chiefly influential in developing the doubly refracting arrangement exhibited by the substances that possessed it.

The force of compression was undoubtedly the agent in forcing the separate particles into optical contact, while that of traction drew them into a line, and tended to dilate the film in the direction of that line, and to draw its particles from each other; or overcome their attraction of aggregation in that direction. It is quite possible, too, that these forces may have exercised some influence in modifying the doubly refracting structure of the substance under examination; but as such a question has no bearing upon our present subject, I have not attempted its solution.

Without expecting any very interesting result, I submitted to examination several of the soft solids which possess double refraction, such as *bees' wax*, *oil of mace*, *tallow*, *and almond soap*. The last of these substances, though in common use, is a very remarkable one. Owing to its particles not being in optical contact, it has a fine pearly lustre, and may be drawn out into long and slender strings. Upon laying a portion of it on glass, it has a quaquaversus polarizing structure, with a tendency to form circular crystals; but when it is drawn out into strings, and laid upon glass, these strings have neutral and depolarizing axes, like the streaks formed by compression and traction. In the present case it is by traction alone that this crystalline arrangement of the particles is produced.

In *oil of mace* and *tallow* a similar effect is produced by compression and traction. With bees' wax the depolarizing lines are still better displayed, and the effect is considerably increased by mixing the bees' wax with a small quantity of rosin.

As the preceding experiments place it beyond a doubt that the optical or crystallographic axes of a number of minute particles are dragged by pressure and traction into the same direction, so as to act upon light like regular crystals, it became interesting to discover the cause of phenomena which certainly could not have been anticipated from any theoretical principle with which we are acquainted. The primary force, and indeed the only apparent one exerted in these experiments, is a mechanical force; but it is not improbable that a secondary force, namely, that of electricity, may be generated by the friction which accompanies the forces of pressure and traction. That such a force is excited with certain crystals will not admit of a doubt; but even if it were developed in every case, this would not prove that electricity was the agent in producing the phenomena under consideration. In subjecting asparagine to compression and traction, I observed, upon placing it in the polarizing microscope, that its particles were moving about under an electrical influence, but in no other case did the same phenomenon present itself to me.

The experiments with soft solids, but especially those made with the almond soap, exclude the supposition that the electricity of friction is the cause of the crystalline arrangement of its particles; though it is not improbable that the sliding of the particles upon one another, as produced by traction, and their mutual separation, as in the case of

tearing asunder mica or paper, may produce enough of electricity to have some share in giving the same direction to the axes of the particles.

When a portion of almond soap is placed upon glass, the axes of its particles lie in every direction, and have no tendency to assume the crystalline arrangement. The forces of aggregation emanating from three rectangular axes, are not strong enough to overcome the inertia, as we may call it, arising from the natural *quaquaversus* adhesiveness of the substance, and from the water interposed between its particles; but when the portion of soap is drawn out into a thread, these resistances to crystalline arrangement are diminished; elementary prisms, or crystals whose length is greater than their breadth, will have a tendency to place their greatest length in the line of traction; and all lateral obstruction to the play of its natural polarities being to a great extent removed, when the substance is drawn into a capillary thread the molecules will have free scope to assume their natural crystalline arrangement.

The application of these views to the powders and particles of hard crystals is not so readily apprehended; but when we consider that the pressure brings the molecules of the substance within the sphere of their polarities, and that the force of traction reduces the compressed film into separate streaks and lines, like the threads of the almond soap, we have reason to conclude, that, even in hard substances, the atoms, when released from their lateral adhesions and brought into narrow lines, will assume the crystalline arrangement.

In the course of these experiments, I have observed in some cases where the crystalline arrangement was very imperfectly effected, a tendency in the atoms to quit their position, as if they were in a state of unnatural constraint, like the particles of silex and manganese in certain kinds of glass which experience a slow decomposition. If this should prove to be the case, either partially or generally, which time only can show, it will doubtless arise from the non-homologous sides of the elementary atoms having come into contact; a condition of the crystalline lines perfectly compatible with the existence of neutral and depolarizing axes, and of the colors of polarized light, provided that the non-homologous sides in contact deviate from their proper position, either 90° or 180°. If we cut a plate of mica, for example, into two pieces, and combine them by turning one of them round 90° or 180°, polarized light transmitted through them perpendicularly will exhibit the same colors as when they were in their natural position, and also the same neutral and depolarizing axes. If the polarized light is transmitted obliquely, the *hemitropism* of the combination, as we may call it, will be instantly discovered by the difference of color of the two plates.

II. Geology.

1. *On the Gold Fields of Victoria or Port Philip;* by H. G. Wathen, Esq., Mining Engineer, (Quart. Jour. Geol. Soc., vol. ix, p. 74, communicated by P. N. Johnson, Esq., F.G.S.)—*General Description, Geographical and Geological.*—A chain of mountains, or rather a series of distinct ranges, runs round the southeastern corner of Aus-

tralia, nearly parallel to the coast line, and from fifty to eighty miles from the sea, forming part of the main chain of the continent, and rising at its highest summit, Mount Kosciusko, to 6500 feet above the sea-level. This mountain chain in Victoria consists of clay-slates, mica-slates, and flinty slates, in successive steps, forming collectively, a recurring series.

The slates are nearly or quite vertical, with a north and south strike, and are intersected by numerous quartz-veins, running at an acute angle with the slates. Vast plains of trap, forming high table-lands, run up to the base of the mountains and probably cover their lower slopes. It is in the valleys and gullies of these mountains, and not very far from their junction with the trappean plains, that the rich deposits of gold are found. The auriferous districts are commonly broken by deep valleys and precipitous steeps. The hills are thickly forested; the soil poor and gravelly, and the surface strewn with angular fragments of white quartz.

Gold-fields.—Gold has been found at several points remote from each other along this zone of mountains; but incomparably the richest deposits hitherto opened in the Colony of Victoria, and indeed in the entire continent, are those of Ballarat and Mount Alexander, the latter far exceeding the former in extent and richness, while even the former is said by Californian miners to surpass in richness and yield all that they have witnessed in that region of gold.

Mount Alexander gold-field.—Mount Alexander lies in latitude 37° South, longitude 144° 20′ East, and is about 75 miles north-west of Melbourne. It was named by the first explorers Mount Byng, and is thus distinguished on many maps. It is a rocky granitic mountain, with a rugged flattened outline, towering some hundreds of feet above the summits of the forested ranges of slate-rocks which surround it, and of which it is the centre and nucleus.

The enormous amount of gold which this district has yielded has chiefly been derived from two valleys with their lateral gullies and ravines. These valleys are known by the names of the streams or "creeks" that run through them. One of these, Forest Creek, takes its rise in Mount Alexander itself; the other, Fryer's Creek, has its source in the high and broken ranges of slate that environ the Mount. Both Creeks are tributaries of the River Loddon. The workings extend five or six miles along the valley of Fryer's Creek, and about ten along that of Forest Creek. At Fryer's Creek gold has been found in large quantities beneath the bed of the stream, near its source, in the upland gullies. Forest Creek, on the contrary, appears to grow barren as it approaches the higher granite country, where it originates. On the banks of the River Loddon gold is found in small quantities, lodged in the crevices of the rocks, but no large deposits have been met with on the river, and even the stream into which Forest Creek runs, though itself only a feeder of the Loddon, proves far less rich than Forest Creek and its mountain affluents. In short, it would seem that the gold had been arrested in the small mountain ravines and gullies, and was never washed down to the large streams. Auriferous sands on river-banks or in alluvial plains are unknown in the Colony. When within 12 inches of the surface, the gold is disseminated in a quartzose

gravel; when found at lower depths, it is almost always imbedded in clay, usually of a very tenacious kind.

Ballarat Gold-field.—The Ballarat gold-field, which is about fifty-five miles north-west of Geelong and Port Philip Bay, lies at the junction of the slates with the trappean country, about seven miles from an extinct and now forest-grown volcano, known as Mount Boninyong. A second similar black volcanic mount rises out of the slate ranges, about ten miles due north of Boninyong. Granite crops out in small patches between the two Mounts.

This auriferous tract is united to that of Mount Alexander by a succession of similar dark forested ranges, rough, rocky, and sterile, strewn over with quartz, and consisting of the same series of micaceous, flinty, and clay-slates.

Volcanic tract.—At the western base of these sombre hills lies a large tract of the most fertile and beautiful country—the garden of Australia Felix—the rich soil of which is the product of decomposed lava. These park-like plains, sprinkled over with groups of trees, are diversified by numerous domelike lava hills, without trees, but of the richest verdure. I have counted no less than twenty-four of these remarkable bold hills from the summit of one of them. The south and east sides are commonly steeper than the others. They are usually flat at the top; but in one of them, which I named Mount Lyell, after the illustrious geologist, there is a small crater, which had the reputation of being fathomless, but which I found to be in fact about 50 feet deep, consisting of an upper cup or crater about 15 feet in diameter, contracting below into a narrow rocky shaft or well, 30 feet deep, and three or four wide. The freshness of the traces of the flow of the lava, which is of a soft and perishable kind, indicates that the epoch of igneous action cannot be very remote. Altogether this volcanic region forms a most interesting subject for geological research and speculation.

Quartz Veins.—The sedimentary rocks are traversed by numerous veins of quartz, about 3 feet wide, of unknown length, in some districts descending to an unknown depth, in others not more than three or four feet deep. These veins or dykes run N. and S., or N. N. E. and S. S. W., and always make an acute angle with the laminæ of the slates. They seem to be the original matrix of all the gold found in the valleys and creeks. The quartz is often intersected by many joints and narrow fissures, filled with a red ferruginous earth, in which particles of gold are disseminated. Gold is also found implanted in the quartz itself, and attached to the sides of its cavities. These auriferous veins were discovered and wrought before the alluvial gold deposits or "Diggings;" and as they were worked with profit by the rude means at the command of the untrained diggers, they would doubtless well repay those who may operate upon them with all the appliances of modern European mining, so soon as the existing social excitement shall have subsided and wages shall have fallen from their present extravagant height. The first gold-working in the Colony was on a quartz vein running through one of the trappean plains so common in this country. The auriferous quartz is not milk-white, but has a delicate yellowish color, and a waxy lustre. That which is much broken and fissured appears richer than

the more hard and solid. Sometimes large boulders of quartz are found deep beneath the surface, in the midst of auriferous clay; but it is remarkable that in such cases the quartz boulders rarely or never contain gold, however rich the clay it lies in may be.

These quartz veins appear, as already said, to be the original seat and matrix of the gold. The slate rocks having undergone continual degradation during the lapse of ages, the quartz veins also have suffered decay and disintegration when their enclosing walls no longer existed; the joints and fissures in the veins of course aiding the destructive process. Hence the gold disseminated in their mass became liberated, and, together with the materials of the quartz veins and slate rocks, were washed down into the gullies and creeks, where the latter formed the beds of clay, gravel, &c., now found in these depressions; whilst the particles, grains, and nuggets (or pepites) of the precious metal by their own weight descended to the lowest of the permeable beds, and into the chinks and cavities of the slate rocks beneath, forming the "pockets" of the miners.

Mode in which the Gold is deposited.—Occasionally the gold grains are seen strewn on the top of the soil. Sometimes they lie 30 feet beneath the surface, and may also be met with in other localities at every intermediate depth. The "Diggings" may however be conveniently classed into two divisions: first, "Surface Workings;" second, "Pit" or "Hole Workings." In the first the gold is either found lying on the surface or (much more commonly) is diffused through the gravelly soil to the depth of six or 12 inches, beneath which is usually a stiff red clay containing little or no gold. These deposites are commonly on the sides and crests of hills adjoining rich gullies. The second or deeper class of workings consists of pits or "holes" from three or four to 25 or even 30 feet deep. In these deposits the gold is almost always imbedded in a stiff clay. When any spot is rich on the surface no gold will be found immediately beneath, and *vice versâ* when rich below it will yield nothing on the surface.

These deeper or Pit Workings are of three kinds:—

1. In the channel of an auriferous creek, at points where the stream is impeded by bars of vertical slates traversing the valley, gold is often found by sinking through the alluvial mud and earth down to the rocky channel beneath. Here the gold is lodged in a grey clay, which fills the chinks and fissures of the slate rock whence the miners extract it by means of knives, spoons, shears, or any other tool they can meet with. Where the bed of the stream expands into an alluvial flat, the auriferous deposit will also increase in width. Such was the first-worked "Golden Point" of Mount Alexander, a local expansion of the bed of Forest Creek. If it should happen that the existing Creek has left its original channel, the run of the gold deposit then quits the modern Creek and follows its ancient channel. These workings in the beds of creeks are commonly from three to ten feet deep. They were the first undertaken at Mount Alexander. The deposits are richest at points where the stream has been impeded in its course, either by frequent sinuosities or by being crossed by a bar of slate as already mentioned.

2. A second kind of deep auriferous deposit is met with in the dry gullies which descend from the higher ranges to the main valleys,

generally with a gentle inclination, from a quarter of a mile to a mile in length. These gullies in some spots are narrowed by the converging hills and sometimes expand into open slopes or flats. Here the gold is commonly found, at from 10 to 20 feet beneath the surface, in a reddish or yellowish clay, lying either upon the fundamental rocks, in the chinks of the vertical slate, or else upon a thick tenacious white or yellow clay, known by the miners as "Pipe Clay." This is sometimes of unknown depth, and sometimes passes imperceptibly into the vertical laminæ of soft micaceous slate. In some of these gullies there is a continuous line of workings half a mile in length. The richest deposit is always found in what appears to be the *ancient channel* or bed of the gully, where the opposite slopes of the rocky gully meet deep beneath the overlying strata of gravel and clay. The breadth of the area which yields gold is usually not more than a few feet, rarely if ever more than a few yards. The superior strata clearly owe their origin to running water. They differ much in composition in different localities. They may be hard or soft—may consist of tenacious clay or of sandy gravel. When first turned up they almost always are of some bright hue of red, yellow, or white; but this soon fades away on exposure to the air. It is remarkable, that these gullies are, with scarcely an exception, on the south side only of the valley.

3. The third kind of deep workings are those on the sides and crests of the low rounded hills or acclivities at the sides of the auriferous gullies. It often happens that the width of an auriferous gully is contracted before it falls into the main valley by spurs from the lateral hills, which, protruding from either side, form a kind of gateway to the gully. In such localities the gold deposit was found to continue across the gully up to the foot of these enclosing hills, and thence up their sides to the rounded crest, where the rich field commonly ceases. In the gully below, the gold-bearing deposit may be at a considerable depth. At the crest of the hill it will also be deep; but intermediately, at the foot of the hill, the "holes" will be perhaps only two or three feet deep, or the gold may in this intervening space be scattered in the surface gravel; so that a section through the hill and gully below would exhibit the gold deposit.

The alluvial strata on the sides and tops of these hills have a general conformity to the present surface, but are extremely irregular, so that two pits, a few yards apart, may present two totally different sections; as though the beds had been deposited by means of strong conflicting eddies and currents. They consist sometimes of stiff red and yellow clays, like those in the gullies; but there also frequently occur beds of a very hard reddish concrete, composed of quartz and slate pebbles. At Ballarat large boulders of quartz, two or three feet in diameter, were found imbedded in the auriferous clays, and, more rarely, detached masses of a conglomerate of fragments of lava, trap, and quartz, imbedding rounded pieces of gold. At these workings the rich "pockets" of gold were commonly associated with a bluish clay, running in irregular veins and patches. So rich was this clay, that 9 lbs. weight of gold have been taken from a single tin-dishful of it, about fourteen inches in diameter and five or six inches deep.

Enormous amounts of gold have been taken from some of these rounded alluvial hills. The yield, however, is not so uniform as in the gullies; a rich spot and a barren may often lie close together. In these deposits, as in those of the dry gullies, the gold is usually imbedded in red or yellow clays, lying immediately on the fundamental slates, or on the "pipe clay." When the gold-yielding clay lies on the rock, small lumps or nuggets of gold will sometimes slip down between the vertical slates.

In conclusion, the methods of separating the gold from the gravels and clays are the same as those used elsewhere in New South Wales and California, and vary of course according to the means at the command of the miners*.

2. *On the Structure of Agate;* by THEODORE GÜMBEL, (Leonhard u. Bronn's N. Jahrb. f. Min., 1853, pp. 152–157; Quart. Jour. Geol. Soc., ix, 259.)—The curious and beautiful appearances afforded by agates have long made them of primary importance in mineralogical cabinets; but until of late years particular attention does not seem to have been paid to the internal structure of these bodies. Dr. J. Zimmerman is the first, to my knowledge, who observed† that the different varieties of quartz—as amethyst, calcedony, carnelian, jasper—formed the concentric layers of the nodules, which were either hollow or occupied with crystals.‡

In the Jahrbuch of the Imperial Geological Institute of Vienna for 1851,§ is a very interesting memoir on the interior structure of agates by Prof. Dr. Franz Leydolt, where he states that, on being submitted to the action of fluoric acid, the amorphous portions are dissolved before the crystalline layers or bands; and the agate surface being thus prepared, it is made use of in printing an exact copy of itself. The six beautiful plates accompanying the memoir perfectly exemplify Prof. Leydolt's views, and show—*first*, that the parts towards the outer surface consist of several spherules variously combined, which are composed of layers of diverse character; *secondly*, that towards the centre of the nodule is a large mass of amethystine quartz, the nucleus of the latter again being formed of very small concentric spherules.

In the *Jahrbuch für Praktische Pharmacie, &c.* 1852, is a short paper of mine on the rotatory motion of matter in the amorphous condition, in which I have shown, that in a sphere of blown glass the material is not homogeneous, but consists of lamellæ overlying one another at varying angles and confusedly distorted. As in the thin pellicle of blown glass the intimate structure of the soap bubble is as it were fixed, so I sought to make further researches by means of experiments on molecular movement, such as can be observed in so many instances. One of the most successful experiments was the use of melted stearine with which very fine graphite had been mixed, spangles of which easily

* Besides the Ballarat and Mount Alexander gold-fields, "diggings" have been opened at Mount Blackwood and on the Moorabool River, near Ballarat; on the Plenty and Yarra Yarra Rivers, N. E. of Melbourne; on the Mitta Mitta River and Lake Omeo, in the N. E. part of the Colony; as well as at several points along the eastern portion of the Boundary-line between Victoria and New South Wales.

† In his Taschenbuch für Mineralogie.

‡ See also Mr. Hamilton's Paper on the Agate Quarries of Oberstein, Quart. Jour. Geol. Soc., vol. iv, p. 215.—Transl.

§ Vol. ii. No. 2, p. 124.

indicated the intimate motion of the mass. By this easy experiment it appears that in some parts there was a strong tendency to the formation of spheres, and which existed even in the interior of the larger spheres, giving rise to smaller spherules.

III. Botany and Zoology.

1. *Fungi Caroliniani Exsiccati. Fungi of Carolina, illustrated by natural specimens of the species;* by H. W. Ravenel, Corr. Mem. of Acad. Nat. Sciences, Philadelphia, &c. Fasc. II.—We are glad to see Mr. Ravenel encouraged to so early an issue of another century of Carolina Fungi. In the quantity and quality of the specimens, this fasciculus is equal and perhaps superior to the first. The paper is superior, though that of the former was certainly good enough. In these respects the collection thus far is equal to anything of the kind we are acquainted with. Rather more than half of the species are exclusively American, some of which are now for the first time published.

We much regret the necessity of finding any fault with a work of such general excellence and accuracy. But we do not remember to have seen a work containing so large a proportion of typographical errors. There are also some unfortunate specimens of Latinity. The first volume contained much fewer blemishes of this kind. In a work containing so little letter-press, and so easy of correction, such errors are the less excusable. M. A. C.

2. *Comparative Anatomy*; by C. Th. v. Siebold and H. Stannius. Translated from the German, and Edited with Notes and Additions, recording the recent progress of the Science, by Waldo I. Burnett, M.D. Vol. I, *Anatomy of the Invertebrata;* by C. Th. v. Siebold. Boston, 1854: Gould & Lincoln.

This work, promised many years since, has at length appeared, and in a form creditable to all parties concerned. As a treatise upon Anatomy, this work of von Siebold and Stannius is well known to naturalists, and has rightly been regarded as the most complete and comprehensive that has ever been published; and its appearance in an English dress together with the additions of the translator, will be regarded as a contribution of no little value, especially to American and English students.

In order to illustrate in brief some of the distinguishing features of the work we cannot do better than quote a paragraph from the Notice of the Translator and Editor. He says: "In the text will be found a lucid yet succinct exposition of the anatomical structure of organs, arranged as far as practicable under distinct types. The details on which this typical summary is based, are comprised in notes which are as remarkable for their erudition as for their copiousness; indeed, the utmost care has been taken in the literature of the various subjects treated, and the student will find here the most reliable and at the same time the fullest reference to the bibliography of nearly every subject in comparative anatomy. In this way, the work as a whole furnishes a complete dictionary of the science, and will prove invaluable even as a work of suggestion and reference, to those who would pursue any special line of inquiry and research in this department."

Dr. W. I. Burnett, who is well known by his own thorough and minute researches in many points in anatomy, has performed his duties as translator with great fidelity, and has also increased largely the value of the edition by his extended additions to the notes and references. He has thus included the most recent results of foreign researches, and has made the work more complete in its exhibition of American Science.

The typographical appearance of the volume is excellent. We have seen no scientific work published in this country that is more creditable in its appearance. It is filled with technical words, and the bibliographical references in the notes are given, as to their titles, in the language in which the works referred to are written. This technicality of terms and the intermixture of some half dozen different languages, must have rendered the work one of great difficulty to the printer. The type is clear, distinct, and apparently new, and the correct relation between that of the text and the notes gives the page a very handsome aspect. As to the orthography of nomenclature, the work will be found to have no superior, for it is evident that the most scrupulous care has been taken in the correct and most approved spelling of scientific terms. We make these remarks, because in these days of rapid book-making, where all is sacrificed to cheapness of sale, it is really pleasant to meet with volumes the comeliness of whose pages delights the eye, equally as their science instructs the mind. We hope that we shall see more in equally excellent style, and from the same enterprising publishing-house, Messrs. Gould & Lincoln, of Boston.

The second volume of this encyclopedian anatomical work is, we learn, in press, and will be issued as soon as practicable. It will comprise the anatomy of the Vertebrata, and we wish Dr. Burnett no better success than that it may prove the mate of the present volume.

G. N. P.

IV. Astronomy.

1. *New Planet, Euterpe* (27).—Mr. J. R. Hind announces the discovery of another asteroid on the evening of Tuesday, Nov. 8, in *Taurus*. It is less brilliant than stars of the ninth magnitude. The following elements were calculated by Mr. Charles Mathieu from observations of Nov. 8, 12, and 17th.

Epoch, 1853, Nov. 8·395103.

Mean anomaly, - - -	336° 1′	
Long. perihelion, - - -	84 2	Mn. eqnx.
" asc. node, - - -	96 16	Nov. 8.
Inclination, - - -	1 26	
Excentricity, - - -	0·18902	
Semi-axis major, - - -	2·26007	
Siderial revolution, - -	3·397 years.	

2. *New Comet*, (Astron. Jour., 66.)—Mr. Robert Van Arsdale of Newark, N. J., discovered a new comet on the 25th of November in the constellation *Cassiopeia*. Its position Nov. 25 at $6^h\ 50^m$ P. M., was R. A. $2^h\ 7^m$, Dec. $+60°\ 12'$. Nov. 30 at meridian passage $9^h\ 5^m$, R. A. $1^h\ 44^m$, Dec. $+54°\ 10'$.

V. Miscellaneous Intelligence.

1. *Contributions to Meteorology,—Mean results of Meteorological Observations, made at St. Martin, Isle Jesus, Canada East, (nine miles west of Montreal) for* 1853; by Charles Smallwood, M.D.—(The geographical co-ordinates of the place are 45° 32′ N. Lat., and 73° 36′ W. Long. Height above the level of the sea, 118 feet.)

Barometric Pressure.—The readings of the barometer are all corrected for capillarity, and reduced to 32° F. The means are obtained from three daily observations, taken at 6 A. M., 2 P. M., and 6 P. M.

The mean height of the barometer in January was 29·757 inches, in February 29·654, in March 29·584, in April 29·654, in May 29·644, in June 29·648, in July 29·479, in August 29·598, in September 29·325, in October 29·500, in November 29·637, and in December 29·456 inches. The highest reading was on the 28th of January, and indicated 30·382 inches; the lowest was also in January, on the 24th day, and was 28·638 inches; the yearly mean was 29·578 inches, the mean yearly range was equal to 0·993 inches. The atmospheric wave of November was marked by its usual fluctuations, the final trough terminated on the 30th day.

Thermometer.—The mean temperature of the air, by the *standard* thermometer, was in January 16°·68, in February 16°·36, in March 29°·68, in April 41°·36, in May 56°·34, in June 68°·66, in July 68°·04, in August 68°·61, in September 58°·04, in October 43°·37, in November 31°·00, in December 16°·57. The highest reading of the *maximum* thermometer was on the 16th of June, and marked 99°·2; the lowest reading of the *minimum* thermometer was on the 27th of January, such was −28°·7 (below zero). The mean temperature of the quarterly periods was, Winter 19°·22, Spring 42°·46, Summer 68°·43, Autumn 44°·10. The yearly mean was 42°·89, and the mean yearly range 59°·27. The greatest intensity of the sun's rays was in August, and indicated 143°·6, the least intensity was in January, and was 64°·0, and the lowest point of terrestrial radiations was −22°·1 (below zero) in December.

The mean humidity (saturation being 1·000) was, in January ·909, in February ·906, in March ·881, in April ·858, in May ·895, in June ·739, in July ·727, in August ·741, in September ·834, in October ·855, in November ·798, in December ·759. The yearly mean was ·825.

Rain fell on 99 days, amounting to 44·201 inches, and was accompanied by thunder and lightning on 17 days. The greatest amount of rain which I observed, fell in September; it commenced at 5.10 P. M., on the 14th, and continued until 5.40 P. M. on the 15th, and amounted to 5·142 inches. I have only observed once, this year, a yellow matter fall with the rain, and that was on the 24th day of September. It was without thunder or lightning, but was accompanied by slight hail. *Snow* fell on 37 days, amounting to 116·81 inches on the surface. The first snow of the winter 1852–3 fell on the 17th day of October, 1852, and the last fell on the 14th day of April, 1853; the whole amount of snow in the winter 1852–3 amounted to 119·10 inches. The river Jesus was frozen over on the 28th day of November. The last steamer left Montreal (on the St. Lawrence) on the 7th of December; the first

steamer arrived at Montreal on the 15th day of April. The winter fairly set in on the 18th day of December.

The amount of evaporation was measured regularly from the 1st of April to the 31st of October, and amounted in April to 1·80 inches, in May 2·51 inches, in June 3·41 inches, in July 3·98 inches, in August 3·16 inches, in September 2·23 inches, in October 2·31 inches. This period includes what I consider could be taken with anything approaching to accuracy, owing to frosty weather.

The most prevalent wind during the year was the W. S. W., the least prevalent was the E.; in the winter quarter the most prevalent wind was N. E. by E., and the least S.; in the spring quarter the most prevalent wind was N. E., and the least so S.; in the summer quarter the most prevalent wind was W. S. W., and the least N.; in the autumn quarter the most prevalent wind was W. N. W., and the least E. The greatest velocity of the wind was on the 14th day of March, and was 32·60 miles per hour. The yearly mean of the maximum velocity was 15·81 miles per hour, the yearly mean of the minimum velocity was 0·32 miles per hour. The quarterly means were as follows: winter, maximum velocity 17·93, minimum velocity 0·25; spring, maximum velocity 16·68, minimum velocity 0·81; summer, maximum velocity 11·23, minimum velocity 0·29; autumn, maximum velocity 16·13, minimum velocity 0·18 miles per hour.

Crows were first seen on the 7th day of March, wild geese *Anser canadensis*, on the 30th day of March, swallows, *Hirudo rufa*, were first seen on the 1st of April; shad, *Alosa*, were first caught in this neighborhood on the 30th of May; fire-flies, *Lampyris corusca*, were seen on the 10th day of June: frogs, *Rana*, were first heard on the 23d of April.

The Aurora Borealis was visible on 39 nights as follows:

January 12th, 10 P. M. Faint auroral arch, dark segment underneath.—13th, 10 P. M. Idem, *Zodiacal light*, bright.

February 1*st*, 10 P. M. Faint auroral streamers.—8th, 4 A. M. Faint auroral light.—14th, 10 P. M. to daylight. Bright auroral arch.—20th, 10 P. M. Faint auroral arch. *Lunar halos* were visible on two nights during this month,—*Zodiacal light* was very bright also on 5 nights.

March 8th, 10 P. M. Faint auroral light to horizon, occasional streamers. *Zodiacal light* still visible and bright.

April 1st, 9 P. M. Low auroral arch, dark segment underneath; 10 P. M. streamers, segment vanished.—5th, 9 P. M. Zenith clear, N. W. horizon clouded with *strati*, Aurora Borealis faint; 9.30, auroral arch 40° high, dark segment underneath at the horizon.—6th, 8 P. M. Faint low arch; 9 P. M., arch 20° broad, dark segment underneath; 9.40, streamers in N. W. of a yellow green color; 10.30, streamers extending to the zenith.—10th, 9 P. M. Low faint auroral arch. *Zodiacal light* very bright on 5 nights during this month.

May 1st, 10 P. M. Faint auroral light.—2nd, 8.40 P. M. Splendid display of clouds of auroral light, forming a distinct arch stretching from the Eastern to the Western horizon, the apex of the arch passing the zenith, extending through the constellations *Bootes* and *Leo*; 9 P. M., auroral clouds in the N. W. low and very near the horizon, arch

very faint; 9.5, arch resumed the same brilliant appearance as at 8.40; 9.10, the whole of the Eastern and Western heavens were lighted up with a splendid display of auroral clouds, assuming various shapes and colors from yellow to crimson, arch disappeared; 9.30, all vanished.—4th, 9.10 P. M. Low auroral arch, dark segment underneath, occasional streamers.—30th, 10 P. M. Low faint auroral light to the horizon. *Lunar halo* visible on the 20th, diameter 63°.

June 14th, 9 to 10 P. M. Auroral streamers, moderate brightness, dark segment underneath.—30th, 10 P. M. Faint auroral light.

July 10th, 9 P. M. Auroral light, dark segment, occasional streamers; 10 P. M., dark segment and streamers vanished.—11th, 11 P. M. Faint auroral light to the horizon.—12th, 10 to 11 P. M. Streamers to the zenith, extending from N. N. W. to E.—18th, 1 to 2 A. M. Low dark arch of auroral light, moderate brightness, occasional streamers.—23d, 10 P. M. Auroral streamers of moderate brightness.—26th, 10 P. M. Faint auroral arch.—27th, 10 P. M. Auroral light to the horizon, splendid streamers. Shooting stars numerous during the month.

August 7th, 10 P. M. Faint auroral streamers, dark segment in the North.—25th, 10 P. M. Faint streamers of auroral light.—31st, 10 P. M. Faint auroral light. Shooting stars numerous from the 6th to the 13th. Comet first seen here on the evening of the 22d day, in the constellation *Leo*, at $8^h\ 20^m$ M. T., R. A. $11^h\ 30^m\ 10^s$, Declination N. 20°·5.

September 1st, 8.50 P. M. Splendid display of auroral clouds, forming four distinct arches, of about 3° in width, with dark segments between, stretching from E. to W. from a point centered as it were in *Arcturus*. The most southern arch passing at its zenith through *Aquila*, the next through *Lyra*, the next through *Polaris*, under which was a dark segment, from which were sent up frequent streamers. These appearances continued with slight intermissions in intensity of color, from 8.50 till 9.50 P. M. The southern or superior arch remained the longest time visible. The northern horizon was lighted up for some time, but faint (until 10.5). Stars of low magnitude were visible through these appearances.—2d, 8.50 to 11.40 P. M. Much the same appearance as last night, but the arches not so well defined. The most southern arch was several degrees south of the zenith. Many floating auroral clouds extending from E to W.—3d, 7.30 P. M. Auroral arches again seen this evening, only two in number, the most southerly a little N. of *Polaris*, very dark segments in the N. to the horizon, occasional streamers.—12th, 10 P. M. Faint auroral light.—18th, 10 P. M. Faint auroral light.—24th, 10 P. M. Faint auroral arch, dark segment underneath.

October 23rd, 10 P. M. Faint auroral light.

November 9th, 10 P. M. Floating auroral clouds—very high wind.—27, 10 P. M. Faint auroral light to the horizon. *Zodiacal light* very bright and well defined apex at *α Leonis*. (Regulus.) Base in East very extended.

December 4th, 8 P. M. Auroral light bright to the horizon.—20th, 10 P. M. Auroral arch; no dark segment.—28th, 10 P. M. Low auroral light to the horizon.

Electrical state of the atmosphere.—The atmosphere has *daily* afforded indications of electricity, varying in intensity, and kind: the

highest tension has been *generally* noticed in the winter season; the tri-daily observations (which could not be condensed) would occupy too much space for the columns of this Journal.

Ozonometer.—Observations have been carefully registered twice daily, for some years, of the amount of ozone present in the atmosphere; the slips of iodized paper are carefully preserved in a dark place, after having been exposed to the atmosphere, shaded from the sun, and rain. As a general rule, rain or snow shows an increase, and so far as my own observations go, a high electric state of the atmosphere *does not* show an increase in the amount of ozone.

St. Martin's, January 25, 1854.

2. *Tornado in Knox Co., Ohio, Jan.* 20, 1854, (Cleveland "Plain-dealer.")—The tornado broke out not far from 3 P. M. and was preceded by a light rain which had fallen all day accompanied by wind and cold. For a short time before the tornado made its appearance the weather is said to have grown rapidly warm, and the wind to have lulled. The hurricane first manifested itself in the western part of Miller township, about eight miles west of south from Mount Vernon. It seemed to spring into full life and passion all at once. No serious traces of its work were seen until it blew down the stable and unroofed the house of John Robinson, residing in the west end of the township. The course of the storm at this time was east by northeast, which course it preserved to the close. It passed on, tearing up fences, unroofing and prostrating some twenty buildings. In its course it entered a piece of woods, half a mile long, and cut a swath through it of the uniform width of a quarter of a mile. The forest looks as if some giant had gone through it with a sickle. Almost every tree is blown down flat upon the ground. The few which remain standing are stripped of their branches, and their trunks are twisted till they look like whip-cords. The appearance of the prostrate woods is very curious. In the center of the storm-track the trees are laid in parallel lines. Toward the outer edge on each side, they gradually diverge from the parallel, till at last they lie quite at right angles to the line of the storm. Along the edges of the path the trees are not at all injured. The storm travelled about ten miles, occupying from two to five minutes, according to different estimates, in passing any one point. It seems to have worn the appearance of a mighty black pillar, reaching from earth to heaven, irradiated by blinding flashes of lightning, and accompanied in its devastating march by the music of a hundred cannon.

3. *Discovery in Photography*, (Edinb. New Philos. Journal, Jan., 1854).—A letter from Berlin of the 17th, says,—It is well known that the paper prepared for photography grows more or less black by rays of light falling on it. One of our young painters, M. Schall, has just taken advantage of this property in photographic paper to determine the intensity of the sun's light. After more than 1500 experiments, M. Schall has succeeded in establishing a scale of all the shades of black which the action of the solar system produces on the photographic paper: so that, by comparing the shade obtained at any given moment on a certan piece of paper with that indicated on the scale, the exact force of the sun's light may be ascertained. Baron A. von Humboldt, M. de Littrow, M. Dove and M. Poggendorff have congratulated

M. Schall on this invention, which will be of the highest utility not only for scientific labors, but also in many operations of domestic and rural economy.

4. *Fishes of Northern New York—Frozen Fish*, (Sci. Amer., January, 1854.)—Our lakes and streams, which, I believe, are the highest fishing waters in the State, and perhaps in the United States, were originally well stocked with the lake and brook or spotted trout. We have yet good fishing in all except lakes Sandford and Henderson, whose waters have been raised from their former level by the construction of dams, thereby destroying their spawning beds. Besides the trout, we have pickerel, perch, and a variety of smaller fish. The pickerel were introduced into Lake Sandford from Schroon Lake, five years ago. The stock originally came from Lake Champlain, though now our pickerel are quite different in appearance, and far superior, both in flesh and flavor, to the Lake Champlain pickerel: perhaps on account of the purity of water here. They have so multiplied in Lake Sandford, that upwards of three hundred have been caught through the ice this winter, weighing from two to fourteen pounds each.

But to the point. I have witnessed, repeatedly, the two winters I have been here, the resuscitation of frozen trout, pickerel and perch, on thawing them out in fresh running water, even after they had been carried for miles.

It is only under certain circumstances, however, that they will revive. If caught on a day when it is cloudy and freezing hard, and if not hurt with the hook, and they freeze immediately on being thrown on the ice, they will revive on being thawed out. But if allowed to toss about in the sun, on a clear day, and probably not freeze for an hour or two after they are caught, then they will never revive.

It is so common a thing, that I have only to go back to the last day I was fishing for an example of it. I went down to Lake Sandford with one of our men, on the 29th ult., and at night we carried home in our packs eleven pickerel, all frozen hard and bent and curved, just as they happened to twist themselves before freezing. We put them into a trough of running spring water, and when thawed out found six of them alive. The others had probably been caught in the warmest part of the day, and died before they froze. The same day fifteen fine brook trout were brought from Lake Andrew, five miles distant, in a pack, and on being thawed out several of them revived, though I did not notice how many. They are, however, a much more delicate fish than the pickerel or perch, and more easily hurt and killed than either of them.

On the afternoon of the 24th ult. I had fished faithfully for pickerel till sundown, without even getting an encouraging nibble; tired at last of that fun, I took out a small hook and line, and soon had twenty-five perch; they froze almost instantly; I strung them on a crotched twig, carried them so for two miles, and when thawed out, found fourteen of them alive, the rest having been hurt either by the hook or the twig.

The pond behind the village, formed by the damming of the river, is full of young pickerel; they are all from three fish put in there last winter—one male and two females; every one of them were brought from Lake Sandford frozen, and were put into the pond after they had

been thawed out in a trough. The male one I caught, it lay on the ice, frozen, for three hours, and then not finding a mate for him, I run a stick through his gills and dragged him home on the snow, two miles, threw him into the trough, and thought no more of him till next morning, when I found him alive and seemingly enjoying himself as well as his narrow limits would permit. I took pity on the poor fellow, carried him down to the pond, and he went off with a dart.

These are but a few instances of what occurs here almost every day the winter through. The fact of their resuscitation, after being frozen as I have described, is known to every one here who is in the habit of fishing in winter, and cannot escape being noticed, as the weather here is cold enough almost all the time to freeze them, and they have to be thawed out before they can be cleaned.

I have heard some say that they have taken trout when frozen, and whittled the fins and tail off, and on being thawed, found them alive; but I have never tried this nor any other experiment with them, and would not vouch for the truth of it. ROBERT CLARKE.

Adirondac Iron Works, Essex Co., N. Y.

5. *American Association for the Advancement of Science.*—The next meeting of the American Association will be held in Washington City, D. C., commencing with the 30th of April.

6. *Cabinet of Minerals for Sale.*—A cabinet of minerals, containing about one thousand specimens, is offered for sale in Philadelphia. It includes both Foreign and American specimens, well selected, and would make a good collection for any Academy or College where there is instruction in Mineralogy. It will be sold low. Address Wm. S. Vaux, Esq., No. 145 Mulberry st., Philadelphia.

7. *Cameroceras trentonense and Orthis Verneuili.*—Mr. Marcou has the authority of de Verneuil for saying that *Cameroceras trentonense* is the same as *Orthoceras communis* of Europe (see page 201 of this volume). But if the figure given by Hisinger is to be relied upon, it is widely different. Wahlenberg's original description reads: "Continet siphonem modicæ crassitiei æquantem decimam circiter partem diametri transversalis totius testæ, eumque ut plurimum inter axin et ambitum tubi in medio situm." But in the C. trentonense, the siphon is marginal and full one-half the shortest diameter of the tube, and as nearly as possible to four-ninths of the longest diameter, the form of the shell being oval in all specimens seen.

De Verneuil cites *Orthis Verneuili* from the Ottowa River, Canada, in Logan's collection, and if this be correct, it is an American species. Mr. Marcou has therefore the authority of de Verneuil for pronouncing both of these species as American; yet there is reason to believe that the facts are otherwise.

8. OBITUARY.—J. E. TESCHEMACHER, (Communicated by the Boston Soc. of Nat. Hist.)—At a meeting of the Boston Society of Natural History held Dec. 21st, the President, Dr. J. C. Warren, spoke of the recent death of one of its members, Mr. J. E. Teschemacher, as follows:

Gentlemen:—Our Society has experienced a great loss in the death of Mr. Teschemacher, one of its most valuable members; and we must

turn aside a moment from the path of science to pay a tribute to his memory. This gentleman, who joined our Society in the year 1835, and has since that time been an able associate in our labors, and a large contributor to the advancement of science in our country, has suddenly terminated his mortal career at the age of sixty-three, from a disease of the heart.

Mr. Teschemacher was a botanist, a mineralogist and geologist, and the records of our Society will show that he studied these sciences not in a loose and general way, but with untiring minuteness and assiduity. Although born on a foreign soil, he became so entirely affiliated with his adopted countrymen, that no one ever considered him in any other light than that of a fellow-citizen, and all regarded him with affection as well as respect.

Our Society, moved by the great merit of Mr. Teschemacher, and the loss they have experienced from his death, have therefore—

Resolved; First, that a record be made in their transactions of the high estimation in which they hold the private qualities and scientific labors of Mr. Teschemacher, as manifested in his excellent papers on botany, mineralogy, some departments of geology, and particularly in his able and practical investigations of the carboniferous formations. We also regard his productions on the composition and improvement of soils as a valuable and permanent contribution to the agriculture of the country.

Resolved; Second, that the President of the Society be requested to prepare some notice of the life and labors of our learned associate.

Resolved; Third, that a copy of these Resolutions, with the preamble and appended notice of his productions, be presented to his family, to the scientific journals of the country, and the daily paper which publishes the proceedings of this Society.

In compliance with the second of the above resolutions the President presented the following notice.

James Englebert Teschemacher, (of Hanoverian extraction on the paternal side,) was born in Nottingham, England, on the eleventh day of June, 1790. At the age of fourteen he commenced his commercial career in a mercantile foreign house of eminence in London, where he evinced application and business talents of a high order; and amid the extensive transactions of mercantile life, in which during a long series of years he was engaged, his fine, comprehensive mind, ever remained unshackled by any of the less elevating habits sometimes contracted in commerce. At an early period of his life he imbibed a taste for studying out of nature's beautiful book; thus acquiring that purity and love of truth so constantly pervading all his thoughts and writings.

In the year 1830 Mr. Teschemacher accepted the offer of a partnership in a house of considerable standing in Havana, and proceeded to Cuba with highly advantageous prospects; but these prospects faded on his approach, and he returned to England. After a brief space he made up his mind to repair to the United States with his family; reaching New York, February 7th, 1832, he finally settled in Boston, where during the space of twenty-one years, he was unremitting in his exertions for his family. Of his untiring zeal and enthusiastic devotion to science we need not speak: his hours of leisure, it may be natu-

rally inferred were few, but those few were employed (apparently as a recreation) in the severer branches of study, which frequently form the labor of a life, even with those who make science their occupation. Truly may he be said to have improved the talents committed to his charge.

The following is a list of his Academic papers and published works:

1835. June 3rd, A report on a specimen of Sulphur.
" July 5th, On a collection of Minerals from Russia.
1837. October 5th, On three species of Trillium.
1838. January 3rd, On a specimen of Moonstone.
" " 31st, On alloys with Nickel.
" February 20th, On Palms.
" March, An account of the Camelliæ.
" November, On the Gomphocarpus fruticosus.
1839. February, On the Lodoviceæ Sechellarum, or Noble Palm.
" June, On the Minerals of Milk Row Syenite Quarry, Charlestown.
1840. April 22nd, On Minerals from New York.
" July 15th, On plants from New Zealand.
1841. February, On plants from Illyria.
" April, On Phosphate of Uranium at Chesterfield.
1841. June, On a new species of Rafflesia from Manilla.
" August, On plants from Kentucky.
1842. March, On fossil Ferns from Mansfield.
" October, On corn from Texas.
" —— On soil from Huron Prairie, Ohio.
" —— On the identity of Pyrochlore with the Microlite of Prof. Shepard.
1843. January, On a slab with dendritic markings, from Newton, Mass.
" February, Remarks on Guano.
1844. —— On Beryls from Acworth.
1845. June, On Melo-cactus, from St. Diego, California.
" November, On Russian minerals.
" December, On Ferns from the Sandwich Islands.
1846. March, Mineralogical notices of Damourite and Pyrrhite.
" —— On fossil vegetation.
1848. January, On fossil vegetation.
" April, On angles of the mineral Arkansite.
1850. February, On the mineral Vermiculite.

Published Papers.

An address before the Boston Society of Natural History.
" " " " Horticultural Society.
" " " " Harvard Natural History Society.
An essay on Guano.

In the Boston Journal of Natural History, vol. ii, 1837:—

Notice of three species of Trillium, found in the vicinity of Boston.

Ibid, vol. iv, 1841.

On a new species of Rafflesia from Manilla.

On the occurrence of the Phosphate of Uranium in the Tourmaline locality at Chesterfield.

Mineralogical Notices—Ibid, vol. v, 1845.

On the occurrence of Uranium in the Beryl limits of Ackworth, N. H.

On Melo-cactus viridescens.

On the fossil vegetation of America.

9. *Outline of the Geology of the Globe, and of the United States in particular, with two Geological Maps and Sketches of Characteristic American Fossils;* by EDWARD HITCHCOCK, D.D., LL.D., Pres. Amherst College, and Prof. Nat. Theol. and Geology. 136 pp., 12mo. Boston, 1853. Phillips, Samson and Company.—This little volume is published as a sequel to the author's "Elementary Geology." It is necessarily brief in its allusions to the geology of different countries of the globe, but all are passed in review, and the subject is illustrated by a colored chart of the world, taken mostly from the geological chart of M. Boué. The latter half of the volume treats of North American Geology. A large geological chart of the United States closes the volume.

10. *The Microscope in its special application to Vegetable Anatomy and Physiology;* by Dr. HERMANN SCHACHT. Translated by FREDERICK CURREY, Esq., M.A. 132 pp. 12mo, with numerous illustrations. London, 1853. Samuel Highley, 32 Fleet street.—The figures in this volume which illustrate microscopic apparatus are confined to a single view of "Highley's Hospital Microscope." The work, after 30 pages on microscopes and the methods of using them, proceeds to the subject of cells, vegetable tissues, and the examination of the different parts of plants, in the course of which there are occasional wood-cuts. Two closing chapters treat of the drawing of objects in Natural Philosophy, especially microscopical objects, and on the preservation of objects for the microscope. The volume is a good companion for the microscope and opens to the student or amateur, subjects and methods of investigation that cannot fail of giving both profit and delight.

11. *Explanations and Sailing Directions, to accompany the Wind and Current Charts;* by M. F. MAURY, LL.D., Lieut. U. S. N., Superintendent of the National Observatory. 6th edition, enlarged and improved. 772 pp. 4to, with 16 plates. Philadelphia, 1854. E. C. & J. Biddle. Published by the authority of Hon. J. C. Dobbin, Secretary of the Navy.—A copy of the new edition of Lieut. Maury's Sailing Directions, reached us just as these pages were going to press, and we have but time to mention its contents. The sixth edition, owing to the demand for the work, has followed rapidly on those preceding. The volume has a miscellaneous character; but bears in all its topics on the great subjects of physical geography and navigation. The topics discussed are the following. The Wind and Current Charts, including general observations on the atmosphere and sea. Universal System of Meteorological Observations, and Report of the Maritime Conference at Brussels. Explanatory Notes for keeping Abstract Log. Influence

of the Gulf Stream on the Trade of Charleston. Currents of the Sea. General Circulation of the Atmosphere, and its probable relation to the Magnetism of the Earth. Red Fogs and Sea Dust. Clouds and the Equatorial Cloud-Ring. Red Sea Currents. Geological agency of the Winds. Saltness of the Sea. Open Sea in the Arctic Ocean. Physical Geography of the Sea. Gales in the Gulf Stream. Wind and Current Charts; Pilot, Thermal and Trade Wind Charts. Routes to and from Europe. Routes to Rio. Passage round Cape Horn. Route to California, and between California and Australia; Routes from Europe and the United States to Australia; and from the Sandwich Islands, home. The general system of Meteorological Observations proposed, if carried out, must give rapid progress to our knowledge of physical geography. With so large an object as the earth for our study, and especially its atmosphere and oceans, whose motions are world-wide in their system, the examinations at a single place, or even many places, are alone of little account. It requires the combined action of civilized nations, with accurate observers spread over all lands and seas, to procure the data for even one great generalization in this department.

12. *The Annals of Science, being a Record of Inventions and Improvements in Applied Science, including the Transactions of the Cleveland Academy of Natural Sciences;* conducted by HAMILTON L. SMITH, A.M. January. 32 pp. 8vo. February. Cleveland, Ohio.—The Annals of Science appeared in January of enlarged size and as a monthly instead of semi-monthly: it moreover embodies the Transactions of the Academy of Natural Sciences of Cleveland. Its pages contain contributions by J. S. Newberry on coal plants of Ohio, who is one of the most able writers on the subject in the country, and is bringing to light many new species; by Dr. J. P. Kirtland, on fishes, also one of our best naturalists; by the editor on microscopes and microscopy; and other papers of importance. The Annals is issued at the low price of one dollar a year. It contains much that bears on practical science, and records of discoveries which are of general interest, and will be a valuable acquisition to any who may become subscribers to it.

13. *Transactions of the American Philosophical Society, Philadelphia*, vol. x, new series, Part III.

Contents—Art. XXII. Description of an extinct species of American Lion; *Felis atrox;* by JOSEPH LEIDY, M.D.

XXIII. A Memoir on the extinct Dicotylinæ of America; by JOSEPH LEIDY, M.D.

XXIV. Chemical Examination of two Minerals from the neighborhood of Reading, Pennsylvania; and on the occurrence of Gold in Pennsylvania; by CHARLES M. WETHERILL, Ph.D.

XXV. On a New Variety of Asphalt; *(Melan-asphalt,)* by CHARLES M. WETHERILL, Ph.D.

XXVI. On the Decomposition of the Alkaline Sulphates by Hydrochloric Acid and Chlorine; by R. A. TILGHMAN.

XXVII. Notes on the Classification of the Carabidæ of the United States; by JOHN L. LE CONTE, M.D.

XXVIII. Revision of the Elateridæ of the United States; by JOHN L. LE CONTE, M.D.

APPENDIX.

Notice of a collection of Fishes from the southern bend of the Tennessee River, in the State of Alabama; by L. Agassiz.

The only information we have at present upon the fishes of the Tennessee River, has been published by Dr. D. H. Storer, who mentions nine species from the vicinity of Florence, Alabama, in the Proceedings of the Boston Society of Natural History for 1845, and of which short descriptions appeared in his Synopsis of the Fishes of North America, in 1846. Having lately received a collection of not less than thirty-three species from the same water system, brought together by the untiring efforts of Dr. Newman, of Huntsville, who has most kindly placed them in my hands for description, it seems desirable that an early notice of the general character of the ichthyological fauna of that region should be published, to serve as a standard of comparison with the fishes of the other western and southern rivers, in the study of their geographical distribution. I arrange them below according to their natural affinities.

PERCOIDS, *Cuv.*—Whether the genera Perca, Labrax, and Lucioperca, are really wanting in the Tennessee River remains to be ascertained. No specimens of these genera were found among those forwarded by Dr. Newman; though many less conspicuous forms were collected. Thus far the genera Grystes, Centrarchus, and Pomotis, as understood at present by ichthyologists, are the only representatives of the family of Percoids in the Tennessee River.

1. Grystes, *Cuv.*—I have already shown in my "Lake Superior" that the genera *Grystes* and *Huro* of Cuvier do not differ essentially one from the other, and must therefore be united into one natural group; moreover when the fishes of Kentucky shall be better known, it may become necessary to substitute for either of them the name of *Lepomis*, introduced in ichthyology by Rafinesque, as early as the year 1820, for the western species of this genus. If I hesitate to make the change now, it is simply because I have not the means of deciding upon the value of his many species. The species of this group are indeed very difficult to characterize. They differ chiefly in the relative size of their scales, the presence or absence of teeth upon the tongue, though Cuvier denies the presence of teeth on the tongue of any of

them, &c. There are besides marked differences between the young and the adults. These circumstances render it impossible to characterize any one species without comparative descriptions and figures. The species from Huntsville, known there under the name of Trout, differs equally from the northern species mentioned in my "Lake Superior," and from that of the Southern States described by Cuvier and Valenciennes as Grystes salmoneus. Its snout is shorter, the posterior end of the upper maxillary extends beyond the hinder border of the eye, the head is higher, and the scales much larger in the dorsal as well as in the ventral regions. No teeth on the tongue. I call this species provisionally *Grystes nobilis*, Ag. It reaches a large size, and weighs occasionally from ten to fourteen pounds.

2. Centrarchus, *Cuv.*—Under this name Cuvier has combined a variety of Percoids agreeing in general form; their body being oval and compressed, and the two dorsals continuous; but these fishes differ from one another in so many respects that they require to be further subdivided.* I shall retain the name of *Centrarchus* for that group of species of which *Centrarchus irideus* may be considered as the type. Thus circumscribed, the genus Centrarchus may be characterized as follows: Body very broad, greatly compressed, above as well as below. Dorsal long and high, gradually rising, without a depression between the spinous and soft rays; spinous portion of the fin largest. Anal shaped like the dorsal, but with fewer spinous rays, extending between the ventrals. Mouth small. No species of this genus has been found in the Tennessee River.

3. Pomoxis, *Rafin.*—This genus was established by Rafinesque for a species closely allied to the *Centrarchus hexacanthus* of Cuv. and Val., and it well deserves to be retained. The body is much elevated and compressed, resembling somewhat Centrarchus proper. Like that genus it has a high dorsal and a high anal, of nearly equal size, and the spinous portion of these fins rises towards the soft rays without a depression; but in Pomoxis the soft portion of these fins is much the largest, whilst it is the smaller in Centrarchus; in Pomoxis the lower jaw is very prominent. The mouth is very large, which is smaller in Centrarchus. I have found representatives of this genus in all the Western States, from the western parts of New York to the Gulf of Mexico, and in the southern Atlantic States, but none in the northern Atlantic States. The species from the Tennessee River, called there Speckled or White Perch, agrees fully with the description given by Rafinesque of his *Pomoxis annularis*, with the sole exception of a *golden ring at the base of the tail*, which may be

* DeKay has contrived to render the genus Centrarchus of Cuvier still less natural, by introducing into it his *Centrarchus fasciatus* and *obscurus*, which truly belong to the genus Grystes. See "Lake Superior," page 295.

faded in the specimens sent by Dr. Newman, from Huntsville. Not having however specimens from the locality quoted by Rafinesque, I must leave it for further investigations to determine beyond any doubt their specific identity or difference. *Centrarchus hexacanthus*, Cuv. and Val., belongs unquestionably to this genus.

4. Ambloplites, *Rafin.*—This is another of the natural genera established by Rafinesque for one of the many distinct types combined by Cuvier and Valenciennes under the name of *Centrarchus*. The well known *Centrarchus æneus* may be considered as its type, though Rafinesque founded his genus upon another species, from Kentucky, which has remained unnoticed since. The genus Ambloplites is easily distinguished from the preceding ones by the structure of its dorsal and anal fins. The spinous portion of the dorsal is much longer than the posterior soft portion of that fin and scarcely half its height, causing a marked depression to appear between the spinous and the articulated rays. The same is the case with the anal, which is also long; but low in its anterior spinous portion. The general form of these fishes is oval, and the body less compressed than in the preceding genera. The species from the Tennessee River agrees in every respect with Rafinesque's *Ambloplites ichtheloides*. It is called at Huntsville Goggle-eyed or Black Perch. In adopting the genus Ambloplites and referring this species to it with Rafinesque's authority I have acted with that discretion due to an author who labored under the greatest difficulties when preparing his work upon the fishes of the Ohio. It is true he himself describes this species as *Lepomis ichtheloides;* but he also suggests the desirableness of distinguishing it generically and proposes a new name for the genus, should it be admissible. Finding it to be so, I do not hesitate in giving him the fullest credit for his suggestion, even though I must add that he has described another variety of the same species under the name of *Ichthelis erythrops*. I have found both these varieties among the fishes sent to me by Dr. Newman, and I have no hesitation in considering them as specifically identical with one another and as agreeing fully with Rafinesque's descriptions. Should naturalists be more generally inclined to correct simply what they consider as errors in their predecessors instead of discarding altogether what they can not at once determine, we should have much fewer of those nominal species in our descriptive works, which are the curse of our scientific nomenclature. *Ambloplites ichtheloides* is much stouter and more elongated than *Ambl. æneus;* body less compressed above; face broader, lower jaw less prominent, and strongly arched from side to side; mouth opens less obliquely upwards; spinous rays of dorsal and anal shorter than in A. æneus; dorsal sprinkled with white spots.

5. Calliurus, *Rafin.*—Among the many Percoids found in the freshwaters of the United States there is one very common in South Carolina, which was first described by Cuvier and Valenciennes under the name of *Pomotis gulosus*, and afterwards referred by them to the genus *Centrarchus*. This species however belongs neither to Centrarchus nor to Pomotis, if we are to consider genera as expressing the same general features under a variety of modifications; for all true Pomotis are fishes with a small mouth, feeding on worms, while P. gulosus has a large mouth like Grystes and is a voracious animal living upon small fishes, which he chases with great energy. Again, Centrarchus has fins widely different in their structure from those of P. gulosus; there being a large number of spinous rays in advance of the anal in Centrarchus proper and those genera mentioned above which have been finally separated from Centrarchus; whilst P. gulosus has only three, like the true Pomotis. Notwithstanding these peculiarities I have been hesitating for a long time to consider P. gulosus as the type of a distinct genus, until I ascertained that there exist many species of this type in different parts of the country, all of which reproduce the essential peculiarities of P. gulosus under a variety of modifications. Upon a careful investigation of all the works in which American fishes are mentioned, I ascertained however that Rafinesque had already established a distinct genus for a species of this type described in his *Ichthyologia Ohiensis* under the name of *Calliurus punctulatus*. It is hardly surprising that this genus should have been overlooked by European ichthyologists and that it should even have escaped the notice of the authors of the great French *Histoire naturelle des Poissons*, for the fishes of the Ohio river have remained entirely unnoticed since Rafinesque, until Dr. Kirtland published his interesting and highly valuable papers upon the fishes of Ohio, in the Journal of the Natural History Society of Boston. Dr. Kirtland however, though the first author who has done full justice to the valuable contributions of Rafinesque to the Ichthyology of the United States, does not mention the species described by Rafinesque, as *Calliurus punctulatus*, and so this genus has remained unnoticed until now. It has occurred to me that it would be but justice to a naturalist, whose labors have been so generally neglected, to call the attention of Ichthyologists to these facts. I subjoin a short diagnosis of the genus *Calliurus:* Body oval, rather elongated, not compressed above. Dorsal long and low in its anterior portion, with a slight depression between the spinous and soft rays; posterior portion of the dorsal shorter than the anterior, though higher. Anal not half the size of the dorsal, with only three spinous rays. Mouth large, opening somewhat upwards, the lower jaw being longer than the upper. The species from Huntsville is identical with Rafinesque's *Calliurus punctulatus*. It is called there Black Perch or Goggle-eye.

6. Pomotis, *Rafin.*—Every ichthyologist must be familiar with the freshwater sunfishes, so common throughout the United States; but it is perhaps not so generally known that the authority to which the genus Pomotis ought to be ascribed is questionable. Indeed, I find it universally ascribed to Cuvier: but that name occurs already in Rafinesque's Ichthyologia Ohiensis, published in 1820, as a subgenus of his genus *Ichthelis*, which he there divides into *Telipomis* and *Pomotis*. It seems therefore probable to me that Cuvier not considering these subdivisions necessary, and finding the name *Pomotis* better adapted to express the prominent character of all the species of this group, adopted the name of Pomotis in preference to *Ichthelis*, and in conformity with an objectionable practice, followed by some naturalists, to which Cuvier however did not adhere in other instances *of applying a new authority whenever the range of a genus is modified*, allowed in this case his name to supersede that of Rafinesque, which I would however restore, in conformity with the more just practice now prevailing. If it were further asked, what should be done with the name of Ichthelis which was proposed by Rafinesque as early as 1818. Whether it should be made a synonym of his own subgenus Pomotis? or disregarded altogether, because Pomotis has come into general use? I would suggest that neither would be the proper course to follow. It is my opinion that in a complete monograph of this group, the name *Ichthelis* should be finally restored to its right and *Telipomis* and *Pomotis* used for such sections or genera as it may become necessary to separate from it, now that the number and diversity of species of this group has increased beyond expectation. This is at least the course I shall adopt when publishing the descriptions of the many new species of this type I have collected in the Southern States. For the present, I limit myself to describing the seven species sent to me by Dr. Newman, six of which are new to science.

1. *Pomotis sanguinolentus*, Agass.—Called Sun Perch at Huntsville. The general outline of the body is that of Pomotis nitida, *Kirtl.*, but the back is more compressed, the dorsal and anal fins are more pointed behind, and the spinous rays are longer, the base of the anal is shorter. The sides of the head are marked with irregular undulating longitudinal lines of a metallic steel blue color, extending from the cheeks across the gill cover to the base of the pectorals and even continuing alone the sides of the body in dotted lines. There are generally four of these lines below the eyes, the first being close to its margin, and extending backwards along and around the border of the opercular appendage and returning, meets the centre of the hinder margin of the eye, but reappears immediately in front of the eye and continues to the edge of the upper jaw. Though the opercular appendage is

rather large, the lateral line is so high near the back, that it is not covered by it anteriorly. The general color is of a reddish brown, mottled with red above and passing gradually into a uniform bright brick-red color prevailing upon the lower part of the body, and sprinkled with irregular light dots.

2. *Pomotis inscriptus*, Agass.—Small species, the outline of which is more elongated than in P. sanguinolentus. The gill covers are marked as in that species with three or four lines of a metallic steel blue color; opercular appendage long, directed more obliquely upwards than in any other species here described, black, with a light border which is a continuation of two of the lines of the cheeks, the one running below the eye, the other terminating behind the eye. Each scale of the back and sides is marked in its centre with a short narrow black line, hence the sides are regularly striped with dark interrupted lines as numerous as the rows of scales. Spinous rays all comparatively long and slender; the passage from the anterior to the posterior part of the dorsal gradual. All the fins except the pectorals are tinged with black at the extremity. General color dark olive above, lighter beneath.

3. *Pomotis notatus*, Agass.—Called Pond Perch at Huntsville. Body more elongated than in P. vulgaris; its upper and lower curve nearly equal. Opercular appendage very short, not extending beyond the base of the pectorals; its hinder margin is orange-colored, with a black spot in front, from which a faint dusky band extends to the eye. The spinous rays of the dorsal and anal are more slender than in P. vulgaris, and the articulated rays are crossed by fewer dotted or broken dark lines. The pectoral fins are long, extending beyond the base of the anal, as in *Ichth. macrochirus*, Raf. The color is of a uniform light olive; the sides, gill cover and belly being silvery; scales not dotted with black as in many similar species.

4. *Pomotis incisor*, Ag.—Also called Pond Perch at Huntsville. This species resembles very closely the preceding, and is considered the same by the fishermen; but its profile is more arched and slants more abruptly; the black opercular appendage is not encircled with a brighter margin. Sides of the head not banded, but of a uniform color throughout. Dorsal and anal not banded, but darker colored than in the preceding species. There is moreover a dark black spot near the base of the hind rays of the dorsal in P. incisor which is wanting in P. notatus. General color of the body the same in the two species.

5. *Pomotis obscurus*, Agass.—Also called Pond Perch at Huntsville. Resembles P. incisor in the outline of the body, except that the profile is still more precipitate and the body somewhat more elongated as well as much stouter, especially in the region

of the head and across the pectorals. The opercular appendage is longer and broader, but also without a light posterior margin. The posterior soft rays of the dorsal are marked with a black spot as in the preceding species, but all the spinous rays of that fin are shorter and stouter. It is a dark colored fish throughout the lower as well as the upper side of the body, almost uniformly brown, the belly only being somewhat lighter in hue. The face and lower jaw are of a leaden color. The fins are all darker than in P. incisor, especially the ventrals.

6. *Pomotis bombifrons*, Agass.—Body higher than in P. obscurus and profile even more arched. Forehead prominent especially over the eyes. Head quite broad and short. Opercular appendage black, and small; a light narrow band runs along its lower margin. No black spot upon the hind part of the dorsal. The last spinous rays of this fin are shorter than in P. obscurus, thus making the passage to the soft rays more abrupt and marked, the soft portion of the fin being almost as prominent as in Ambloplites and Calliurus when compared with the spinous rays. Body light brown, fins lighter colored; scales of the belly and sides dotted with golden orange. The face and under jaw have not the leaden color of P. obscurus. Considering the peculiar form of the vertical fins and of the forehead, it may become necessary to separate this species from the other Pomotis. Indeed, I know already several species which agree in these respects with one another and must at all events form a distinct group in the genus.

7. *Pomotis pallidus*, Agass.—This species resembles P. incisor in the outline of the body, the nature and coloration of the scales, and in the size and form of the fins, but it differs greatly from it by its large mouth, the free extremity of the upper jaws reaching the vertical line of the middle of the eye, by the presence of teeth upon the palate, and by the ventral fins being placed immediately under the pectorals. The black opercular appendage which is very short, has a narrow orange border behind. There is a black spot at the base of the posterior rays of the dorsal. Both dorsal and anal are marked by one or two dark stripes; the caudal is crossed by several dotted vertical lines. There are eight or nine dusky bars across the sides, between the head and tail. This species bears the same relation to Pomotis, that Pomoxis bears to the true Centrarchus, in the size of the mouth, and the form of the body, and I have no doubt it will some day become the type of a distinct genus.

ETHEOSTOMOIDS, *Agass.*—There are comparatively few natural families in the animal kingdom so limited in their geographical distribution as to be entirely circumscribed within the boundaries of a single continent, and these few belong mostly to the type of Vertebrata. Though among fishes we should least ex-

pect such local groups, considering the greater uniformity of the conditions of existence prevailing in the medium they inhabit, when compared with the main land, yet there are several families of this class, the geographical range of which is quite limited. I need only mention the Goniodonts of South America, the Labyrinthici of the Indian Ocean and the Sunda Islands, the Lepidostei of North America, &c. Another natural family thus located within narrow limits is that of *Etheostomoids*, which I have for the first time characterized in my work "Lake Superior," p. 298. This family is founded upon the genus *Etheostoma* of Rafinesque, to which are added the genera *Pileoma* and *Boleosoma* of Dekay (of which the genus *Percina* of Haldeman is a synonym) and my genus *Pœcilichthys*.* The three first of these genera were referred by their authors to the family of Percoids; but the absence of an air-bladder and of pseudobranchiæ, and the incomplete suborbital arch precludes such an association. Indeed these fishes are more closely allied to the true Cottoids and in particular to the genus Gasterosteus than to the Percoids, though the want of connection between the single suboperculum and the preoperculum forbids also a more intimate alliance with that family. The form of the ventrals of the Etheostomoids reminds us somewhat of those Gobioids in which the two ventrals are distinct. Since the publication of the work above mentioned, I have become acquainted with three new genera of this family, for which I would propose the names of *Hyostoma*, *Catonotus*, and *Hadropterus*.

The more extensive knowledge I have acquired of this family by these recent accessions enables me to give more precision to the characters assigned at first to its genera; as follows:

1. Etheostoma, *Rafin.*—Head elongated pointed; mouth terminal, widely open, not protractile, broad; jaws of equal length. Opercular apparatus and cheeks bare. First dorsal distinctly separated from the second. Anal and second dorsal smaller than the

* The genus *Pœcilichthys* was first mentioned under the name of *Pœciloroma*. Being however at the time of its publication far away from Cambridge, and unable to consult my library or any other, I did not perceive that that name was already preoccupied; I would therefore change it now to Pœcilichthys. Several new species of this genus have been discovered since. One described by Dr. Kirtland as *P. erythrogaster* from the vicinity of Cleveland, Ohio. Ann. of Sci., Jan., 1854, p. 4. Another collected by Mr. Geo. Stolley in the Osage River, Mo., remarkable for its brilliant colors, the body being light brown, with dark black lines upon the sides of the back and with broader transverse bands alternately black and orange red, especially bright upon the sides of the tail; dorsals banded with black, white and red. I call this species *P. spectabilis*. Another found by Dr. L Watson in small creeks near Quincy, Illinois, similar in color to the preceding but without black stripes along the back, also less compressed. I call this species *P. versicolor*. Specimens of this species were also received from Osage River. A fourth species from the Osage River, Mo., also discovered by Mr. Geo. Stolley, is of a greenish color mottled with black, the second dorsal, the caudal, the anal, the ventrals and the pectorals being dotted all over with minute dark specks. I call this species *P. punctulatus*.

first dorsal, but equal to one another. Caudal lunate. Type of the genus: *Ethblennioides*, Raf.

2. Catonotus, *Agass.*—Head elongated, obtuse; mouth terminal, widely open, not protractile, lower jaw longer than the upper. Opercular apparatus, cheeks and neck destitue of scales. First dorsal much lower than the second, with clubshaped rays when full grown; membrane of this fin extending to the base of the second dorsal. Anal smaller than the second dorsal. Caudal rounded. Only one species known: *C. lineolatus*, Agass., discovered by Dr. L. Watson in small creeks near Quincy, Ill. The whole body olive green with close narrow interrupted black longitudinal lines; transverse lines of the same color across the caudal.

3. Pileoma, *Dekay.*—Head conical, pointed, truncated at the end, in form of a hog's snout; mouth moderate, in form of an oblique arc of a circle, opening below the end of the snout, very slightly protractile. Lower jaw shorter than the upper. Operculum and cheeks scaly. Membrane of the first dorsal not reaching the base of the second. Anal smaller than the second dorsal. Caudal truncate or slightly lunate. Type of the genus: *P. caprodes.* (*Etheostoma caprodes*, Rafin.)

4. Hadropterus, *Agass.*—Head conical, obtusely pointed, rounded at the end; mouth moderate, terminal, not protractile, jaws nearly equal. Operculum and cheeks scaly. Membrane of the first dorsal extending to the base of the second. Anal and second dorsal large and equal. Caudal truncate or slightly lunate. Only one species known: *H. nigrofasciatus*, Agass. From the neighborhood of Mobile, Alabama. Discovered by Albert Stein, Esq. Brown above, lighter below, with transverse black bands, wider in the middle than nearer to the back or the belly.

5. Hyostoma, *Agass.*—Head short, blunt, rounded, with swollen cheeks. Mouth comparatively small below the snout, slightly protractile. Lower jaw shorter than the upper, which may be concealed in a deep furrow below the snout. Opercular apparatus and cheeks scaly. First dorsal long, but not reaching the base of the second. Anal smaller than the second dorsal. Caudal slightly lunate. Only one species known: *H. Newmanii*, Agass. Discovered by Dr. Newman in the vicinity of Huntsville, Alabama, where it is called "*Salmon.*" This fish is uniformly brown with irregular transverse black blotches. A red stripe along the base of the first dorsal.

6. Pœcilichthys, *Agass.*—Head short and strong, tapering into a rounded snout. Mouth terminal, proportionally broad, not protractile, though the maxillary bone be moveable. Opercular apparatus scaly, cheeks bare. First dorsal distinctly separated from the second. Anal smaller than the second dorsal. Caudal truncate or slightly rounded. The species of this genus are among

the most brilliant freshwater fishes in the world. Type of the genus: *Etheostoma variatum*, Kirtl. Several new species are mentioned in the note above.

7. Boleosoma, *Dekay.*—Head short, rounded; mouth below the end of the snout, small, horizontal, slightly protractile. Opercular apparatus and cheeks scaly; neck scaleless. Membrane of the first dorsal reaching the base of the second, though the two fins are distinctly separated. Second dorsal much larger than the anal. Caudal rounded. Type of the genus: *Boleosoma tessellatum*, Dekay. For references to other species, see "Lake Superior," page 299.

All the representatives of this family are confined, as far as we know, to the fresh waters of North America; not a single species having thus far been noticed either in Europe or Asia. To this circumstance we must no doubt ascribe the total neglect of the genus Etheostoma of Rafinesque by European ichthyologists.

The genus Hyostoma is the only type of this family I am acquainted with from the southern bend of the Tennessee River. It is true, Dr. Storer has described two species of Etheostoma from the vicinity of Florence, Alabama, but they do not seem to occur farther east: at least I have found nothing to remind me of his species in the collection forwarded by Dr. Newman.

It is a fact worthy of notice that not a single species of Gasterosteus has as yet been discovered in the Mississippi River or its tributaries, or in any of the rivers emptying into the Gulf of Mexico. I have also searched in vain for them in the southern Atlantic states, though they are common in the northern states and in the waters emptying into the St. Lawrence.

SCIÆNOIDS, *Cuv.*—In the old world no representative of this family is known to inhabit the freshwaters, whilst in North America a remarkable species has been found in Lake Champlain, Lake Erie, Lake Ontario and the Ohio River, which truly belongs to this family and has generally been referred to the genus Corvina, under the name of *Corvina Oscula*. It should however be remarked that this species is but remotely allied to the genus Corvina and must in reality be considered as the type of a distinct genus, which has already been characterized, thirty-four years ago by that indefatigable naturalist, Rafinesque, under the name of *Amblodon*. Nobody has however thus far taken the trouble to examine the value of this genus, nor even to state on what ground it has been rejected by those who have incidentally noticed it as a synonym of Corvina. The truth is that Rafinesque was right in considering this Corvina Oscula as a distinct genus, the characters of which he has well defined, as may be seen by comparing his description in the *Ichthyologia Ohiensis* with that below. Moreover I have lately ascertained that there are several

species of Amblodon in different parts of the United States and that this type is not limited to the Northern States but extends west as far as the western parts of Missouri and South as far as Louisiana and Alabama.

Amblodon, *Rafin.*—External characters of Corvina, combined with the form and appearance of Pogonias. Upper pharyngeals distinct, covered with broad, hemispherical teeth closely set, like pavement stones and arranged in regular rows; outside of these are a few small pointed teeth. The lower right and left pharyngeals are soldered together into a broad triangular plate, covered with teeth of the same kind and arranged in the same manner as upon the upper pharyngeals. In the genus Corvina the lower pharyngeals are distinct as the upper ones and support short conical teeth not numerous, nor closely set. From want of a sufficient number of specimens I am unable to determine whether the specimens from the great Lakes are specifically identical with those of the Ohio River described by Rafinesque as *Amblodon grunniens;* but I have ascertained that the species of the Ohio River differs from that of Huntsville, which I call *Amblodon concinnus*, Agass. This species differs from A. grunniens in having the body less elongated, the profile steeper, and the dorsal fin placed further forwards. The profile is most arched immediately over the upper attachment of the preopercle, in A. grunniens it is most prominent over the opercule. The dorsal fin ends slightly in advance of the base of the pectorals; in A. grunniens behind these. The serrated edge of the preopercle is directed more obliquely downwards and backwards, making the inferior angle of the preopercle more acute. This species is known in the Tennessee River by the name of Drum. It reaches there the weight of fifty pounds.

Amblodon lineatus, Agass.—This species sent to me by Mr. Geo. Stolley from the Osage-River, Mo., resembles more A. concinnus than A. grunniens, but the head is shorter; the prominence of the forehead is nearer the dorsal fin, immediately over the opercle, thus having a less arched profile. The anterior border of the eye nearly reaches the profile of the head. The spines of the dorsal fin are bent more backwards. The dark coloration of the centres of the scales, especially in younger specimens produces the appearance of regular lines following the direction of the rows of scales, hence the name of this species. It grows also very large, and bears in Missouri the same name of Drum as the species of the Tennessee River. Mr. Stolley informs me that the Amblodons are very sluggish, and live at the bottom of muddy waters, where they are often seen progressing slowly, raising as it were, clouds of dirt before them, now lying upon one side of their body, then turning upon themselves or

plunging headlong into the soft ground with their body in a vertical position. They feed upon worms, and small shells, large numbers of which are often found crushed to pieces in their stomach; they however bite occasionally at a minnow.

Esoces, Cuv. (Joh. Müller.)—Though we have only the genus Esox representing this family in North America, it is perhaps not superfluous for me to state that I agree with the modifications J. Müller has introduced in this group since it was first established by Cuvier. We have one species from the Tennessee River, called Pike at Huntsville.

Esox crassus, Agass.—This species agrees fully with the type of Esox reticulatus in having both the operculum and cheeks covered with scales. It is, however, a much deeper fish than *E. reticulatus;* its scales are larger and nearly of an hexagonal form. The scales of the preopercle and cheeks are as large as those of the body; those on the opercle are smaller. The superior orbital ridges are more prominent; the depression between these ridges is deeper. The anal and caudal fins are shorter. The body is marked as in Esox reticulatus. The genus Esox has a very wide range in North America, but there is no difference of structure between those of the Canadian Lakes and the western waters, and those of the Atlantic lakes and rivers, as Mr. Girard affirms in a notice recently published in the Proceedings of the Academy of Natural Sciences in Philadelphia (1853, page 386). In the first place my Esox Boreus, from Lake Superior, does not belong to the same type as Esox Estor, its cheeks being covered with scales. Moreover, I know already three species from the western waters, one of which is noticed above, the cheeks and operculum of which are as completely covered with scales as in Esox reticulatus. There are in reality more species of the type of Esox reticulatus, in the western waters and the Canada lakes, than of the type of Esox Estor, and far from excluding one another these types occur there together. As to the application of the names Pike and Pickerel to the different type of our Esoces, it cannot be justified, since such a use would be a scientific sanction of the misapplication of English names to our native animals, which has already led to so much confusion. Unless applied as a generic apellation, the name *Pike* must be retained for the European Esox Lucius, to which only it belongs by right; whilst the name *Pickerel* designates the young of that fish. It would be quite as advisable to introduce in our scientific nomenclature the name of *Calf* to distinguish the Bisons from the type of our domesticated cattle, as to apply the name Pickerel to any particular species or set of species of the genus Esox.

(To be continued.)